CALIFORNIA FISH AND GAME

"CONSERVATION OF WILD LIFE THROUGH EDUCATION."

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WATER POLLUTION PROBLEMS IN CALIFORNIA[1]

By PAUL A. SHAW and C. L. TOWERS
California Division of Fish and Game

Extensive reports on water pollution may be found in the current literature of various federal, state, conservation and other agencies. Many are scientific, covering the deleterious effect of pollutants on fish life, details of stream surveys, purification and treatment methods, etc. Other papers, particularly those from the National Resources Committee on Water Pollution, have dealt with administrative, economic, educational, cooperative and enforcement aspects of this nation-wide hazard, looking toward a workable program of control.

Considering the excellent references available, it would appear unwarranted to present a technical discussion and we will therefore confine our remarks to the law which guides our activities, then attempt to portray, more or less pictorially, a few of the detrimental conditions we face from day to day in California. We do this with the thought of stimulating an increased demand on the part of the public and further endeavor on the part of industries and municipalities toward maintaining clean waterways. Public demand for less contamination of our recreational resources is becoming more insistent, and activity of private interests in regulating their own industries is more evident. It is believed the time will come when former pollutors will take equal pride in backyard (public water) cleanliness and frontyard (national advertising) attractiveness.

Surveys of the National Resources Committee indicate that states having strict pollution statutes accomplish little more than states with ineffective laws. Notwithstanding this fact, we feel that vigorous enforcement would reveal effective differences in state laws, for, in the final analysis, any action that *can* be taken is dependent on the existing law. Whether or not action *is* taken, to the extent of the existing law, will depend in a large measure on the attitude of the public, particularly those who utilize our natural resources, and on their support of adequate agencies to carry out its provisions.

Experience in California indicates definitely that fair but firm law enforcement accelerates the rate at which improvement is effected. While many instances of remedial action have resulted from educational work, the same effort has been obviously more effective when backed by statute. Education may be the standard on which humanity is built, but we should remember that even a baby is chastised for its misdemeanors and that ofttimes a spanking (law enforcement) is the best education when the principals fail to accept the right road through suggestion or cooperation.

[1] Submitted for publication, August, 1937.

Section 481 of the California Fish and Game Code, which is the basis of activities by our pollution detail, reads as follows:

> "It is unlawful to deposit in, permit to pass into, or place where it can pass into the waters of this State, any petroleum, acid, coal or oil tar, lamp black, aniline, asphalt, bitumen, or residuary product of petroleum, or carbonaceous material, or substance, or any refuse, liquid or solid, from any refinery, gas house, tannery, distillery, chemical works, mill or factory of any kind, or any sawdust, shavings, slabs, edgings, or any factory refuse, or any lime, any occulus indicus, or any slag, or any substance or material deleterious to fish, plant life, or bird life."

It will be noted that this law specifically prohibits a large number of solids, liquids and sources; further, the discharge of liquid or solid refuse from a mill or factory of any kind is prohibited; and finally, the statute covers any substance or material deleterious to fish, plant life, or bird life, thus providing in its entirety an extremely

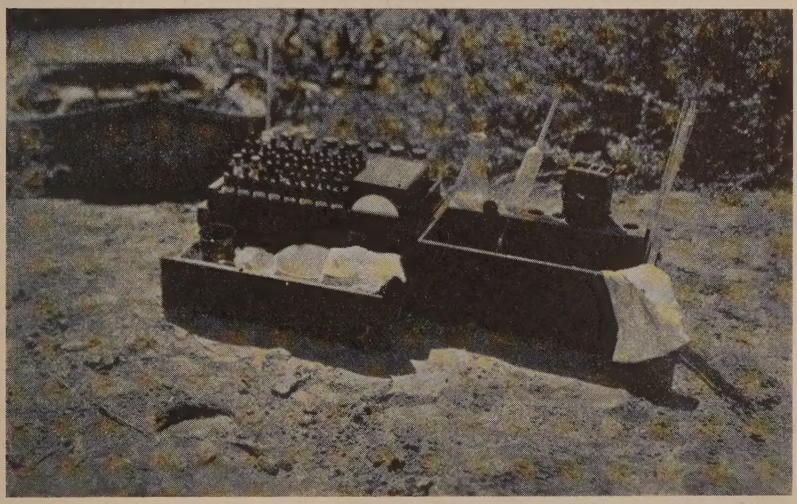

FIG. 45. Field kit used for chemical analysis.

broad law through which pollutants of a visible nature are largely restricted and by which pollutants of an invisible nature may be controlled should investigation reveal their character as harmful.

It should be obvious that considerable judgment must be exercised in enforcing the provisions of such an inclusive statute, and so, while the statute forms the nucleus of the enforcement program, the work is specialized to the extent that correlated programs of scientific investigation, cooperation and education are essential to successful accomplishment.

We have solicited and received remarkable cooperation from agencies such as the U. S. War Department through their district engineers, the U. S. Customs, the U. S. Coast Guard, State and local health departments and others who are charged with the enforcement of similar or related laws. Further cooperation through prosecuting agencies, judges, sportsmen's organizations, chambers of commerce,

representatives of certain industrial groups and many individuals has materially aided in our program. Throughout the work, field, laboratory and experimental investigations are conducted to determine existing conditions and to serve as evidence and justification for action. Figure 45 shows a type of field kit used for stream surveys and chemical analysis. Figure 46 shows representatives of the State and the U. S. Coast Guard collecting a sample containing oil.

In general, pollutants of a visible type are easily traced to their source, their effects on aquatic environment are well established, and the necessary procedure is largely a matter of law enforcement. On the other hand, pollutants that we here classify as invisible may take their toll of fish life before recognition of their presence, resulting in aquatic catastrophes or barren water areas; or, if the source is known, the determination of their deleterious character may involve complete analysis and extensive field surveys to establish a sound basis for enforcement.

FIG. 46. Coast Guard and Division of Fish and Game officers collecting oil samples.

However, it should not be concluded that detailed investigation is limited to invisible pollutants. To illustrate this point there was recently reported a serious degree of oil pollution at a recreational beach on a Sunday morning when some 60,000 people anticipated a pleasant holiday. The condition they found is well illustrated by figure 47. One of the group was righteously wrought up to the extent of paying a $28 long distance telephone call to report the situation to Washington. While there was no apparent source of the contamination, investigation by one of the pollution detail in cooperation with the Coast Guard, covering data on tides, wind, drifts, movement of ships, etc., revealed the probable source as being a vessel that had fueled in a nearby harbor on the preceding night. The ship had cleared port but instructions were wired ahead and the vessel was boarded by the Coast Guard for the purpose of securing an oil sample. Laboratory analysis of this sample compared with an analysis of oil on the water and beach proved their identity, the technical data thus serving as definite prosecuting evi-

dence. The realization that no effort will be spared in tracing down negligent crews and others who thoughtlessly despoil our natural resources, is having a very salutary effect in decreased carelessness and consequent aquatic improvement.

Educating potential pollutors in the necessity for extreme care in handling products capable of causing damage is well illustrated by the recent and more rigid instructions issued by shipping concerns on oil

FIG. 47. Typical oil covered beach.

pollution. The following quotation is the translation of instructions issued by a Japanese shipping company:

"January 8, 1937

"To Captain and Chief Engineer:

Subject: Request for caution against allowing oil to flow within Los Angeles harbor.

It is needless to state that the authorities in any harbor are especially strict in regard to the handling of oil. Particularly is the case true in respect to the prevention of the leakage and flow of oil.

Recently the port authorities of the Los Angeles harbor in North America had added stringent requirements to the extent that several of our Japanese vessels have been cited for negligence and assessed huge fines.

1. Scupper pipes should be closed with wooden stoppers and further made fast by applying hard cement prior to entering port.

2. In the event that flow and leakage should continue despite every precaution, all effort should be made to remove the oil from the surface of the water and every measure taken in order that the port authorities can be satisfied of the steps taken to abide by the regulation.

3. All remnant liquid within the bilge and oil tanks should be emptied after leaving, 50 miles beyond the harbor. A penalty is liable should such offense occur within 50 miles of the harbor.

Further precaution is requested on all other regulations as well.

Shipping Company
Kobe, Japan"

Major oil companies have issued equally rigid regulations including instructions that bilge or ballast should be emptied 50 to 100 miles from shore. The following quotation is from a notice released by the District Engineer, U. S. War Department, on July 10, 1937:

> "The navigable jurisdiction of the U. S. extends over the coastal waters to such distance seaward as may be necessary to give full effect to the laws for the protection and preservation of the navigable waters of the United States.
>
> "This distance is not controlled by any special limits of three or twelve miles, which may have been set up for other special purposes, but is an assertion of the right of the United States to prohibit the doing of anything which tends to affect the navigable waters contrary to existing law."

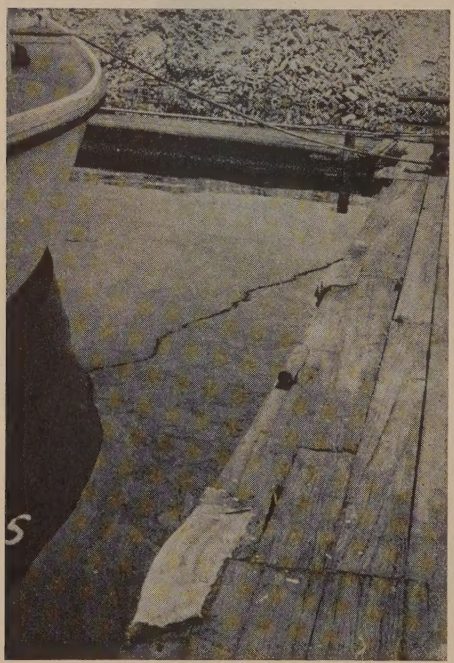

FIG. 48. Loading spill resulting from careless pumping.

The thought expressed in the above paragraphs is similar to the intent of Section 481 which makes it unlawful to "place where it can pass into the waters of this state* * *."

The present day regulations are in considerable contrast to the story heard a few years back revealing the probable instructions given to the crew of a foreign vessel with the hope of "getting by." On being apprehended while pumping oily bilge water in a local harbor the alibi given was, "we thought it was O.K. since the sun had gone down, for we understood the California law required bilges to be pumped at night."

It is impossible to estimate in dollars and cents the enormous amount of damage done annually along our coastal waters and beaches from petroleum products originating from wells, refineries, fueling terminals, bilge and ballast pumping and other sources. This damage is not to marine life alone but affects fishing, hunting, aquatic sports and all beach recreation, together with the ever present fire hazard.

Figure 47 is a good illustration of conditions resulting from bilge pumping or from careless fueling as shown in figure 48. Imagine spending hours planning a family holiday and then have the children tarred and sanded as shown in figure 49. Can you guess what mother said while trying to do the Monday wash? Or, what dad had to say while repainting his boat and cleaning the line and reel after rowing through a patch of California's "black gold"?

And now consider for a moment one of the hazards to marine life. Figure 50 shows the highly prized grunion, *Leuresthes tenuis,* during the spawning period on a sandy beach. These fish spawn at peak tide, and the eggs remain in the sand to hatch at another high tide some two weeks later. The presence of oil on the beach while spawning or during the period of incubation is a definite threat against the existence of this species. The danger of death by oil applies equally well to other forms of aquatic life, both

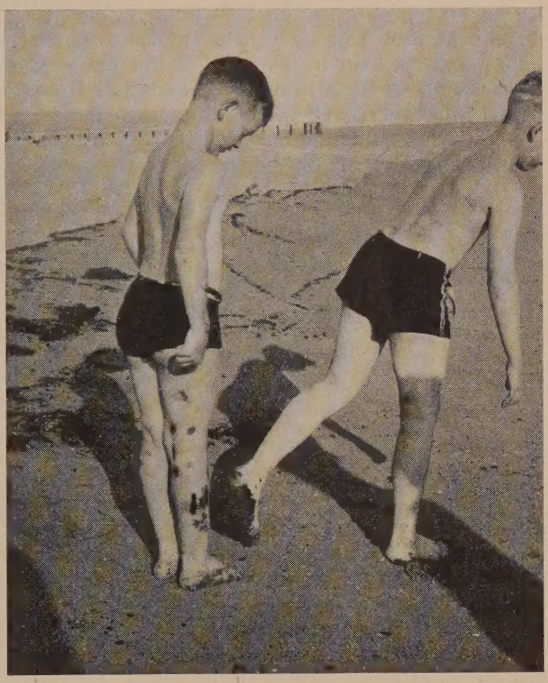

FIG. 49. Children coated with oil and tar.

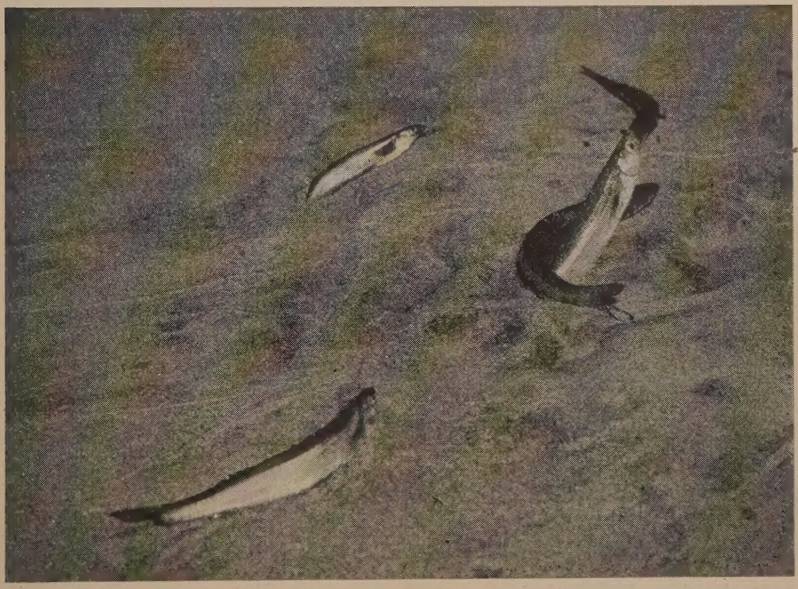

FIG. 50. Grunion spawning on sandy beach. Photograph by "Dick" Whittington.

in the water and on the tide lands. You will note in figure 51 how an oil operator will sometimes conduct his enterprise in such a deplorable way that the lightest of rains may carry surface oil to storm drains or sewers as shown in figure 52, from there to eventually flow into State waters (Fig. 53).

In certain instances our attention has been drawn to installations where thousands of dollars have been spent on a good start, but which

FIG. 51. State waters endangered by failure to provide safety measures controlling oil drainage.

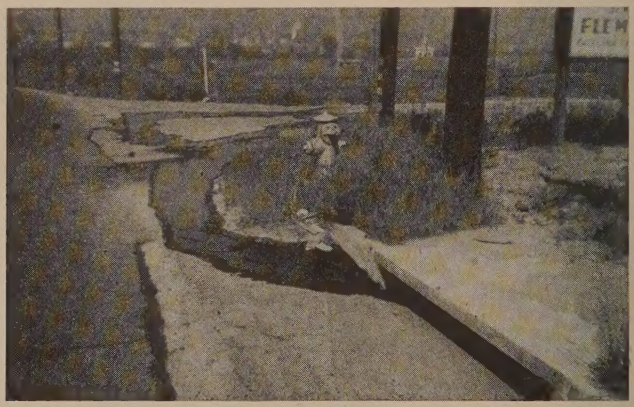

FIG. 52. Oil flowing into storm drain.

through inadequate forethought have proved disastrous. For example, a perfectly constructed wall for a waste oil sump can be an engineering masterpiece to all appearances and yet prove faulty when Father Neptune gets a little angry. The situation in figure 54 would not have happened had the cement been laid to bedrock or deep enough to prevent the foundations being washed away. Again, a tank may appear

satisfactory to hold oil and yet not accomplish that purpose, as may be seen in figure 55.

Faulty installations as shown, and other sources of oil pollution, are responsible for huge losses of waterfowl yearly. The helplessness of an oil coated duck is shown in figure 56. Birds coated in this

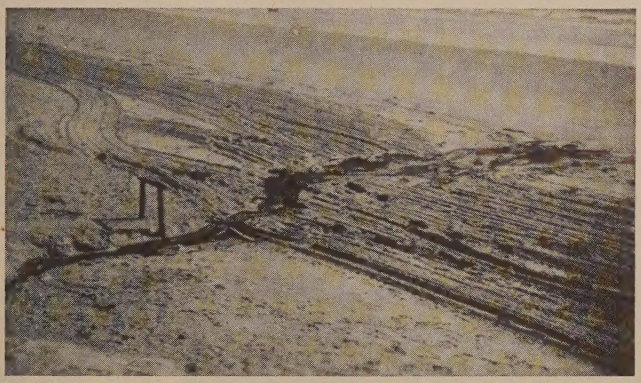

FIG. 53. Oil flowing onto beach from storm sewer.

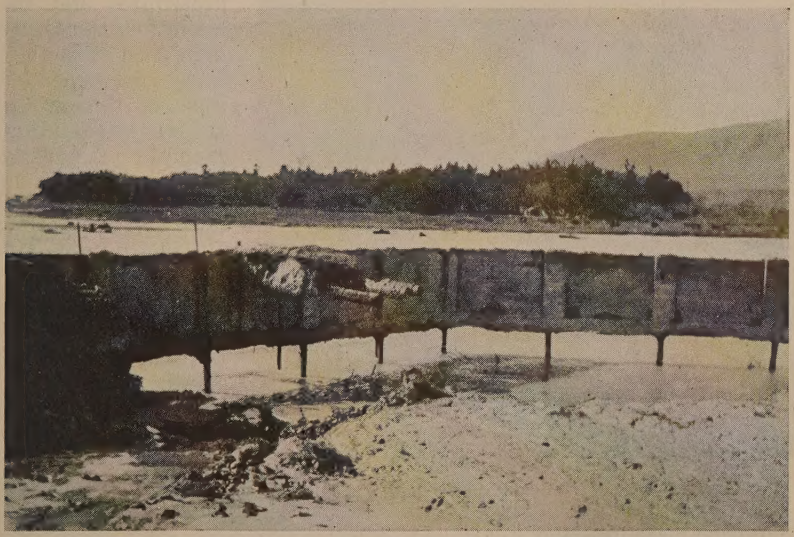

FIG. 54. Oil sump undermined by storm water.

manner seldom fly again and eventually die of starvation. Similarly, oil sumps often become death traps for birds as noted in figure 59. In such cases, burning the sump with the aid of lighter oil to form a solid crust or installing cross wires to discourage birds from alighting has been effective.

However, the situation is not quite so bad as the foregoing pages would indicate, and we do not wish to lay too much complaint at the door of one of our largest and most essential industries. This entire problem can be handled in a way to prevent damage to our natural resources and annoyance to the public, for experience with recommended methods of prevention indicates that the major sources of oil pollution can be eliminated by conforming to approved practice.

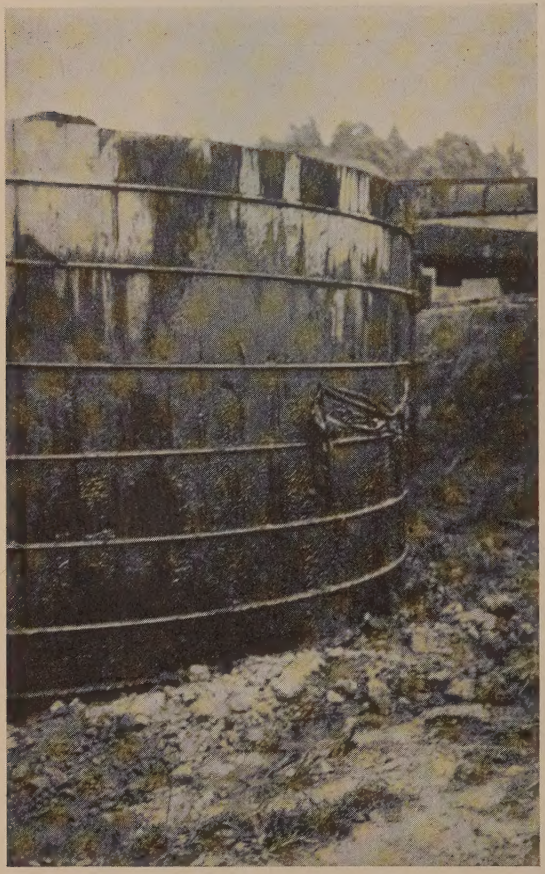

Fig. 55. Leaky oil tank.

The American Petroleum Institute, the membership of which includes a majority of the larger oil companies, carries on continuous investigations relative to proper waste disposal and has published a series of bulletins detailing procedures and installations constituting good practice. The recommendations of this group are an outstanding example of sincere effort on the part of an industry to prevent damage, and it may well be said that the major oil companies operating in California have cooperated to a high degree, spending thousands of dollars annually to comply with requests for improved facilities and preventative measures, and to aid us in every way possible.

Figure 57 indicates one type of separator installed for the purpose of removing oil from waste water. The accompanying diagram (Fig. 58) shows the essential features of one system for handling waste water contaminated by oil.

Separator skimming ponds and sumps of varied design and construction are maintained and operated as part of oil well, refinery, and railroad roundhouse practice throughout the State.

FIG. 56. Helpless, oil coated duck.

FIG. 57. An oil and water separator.

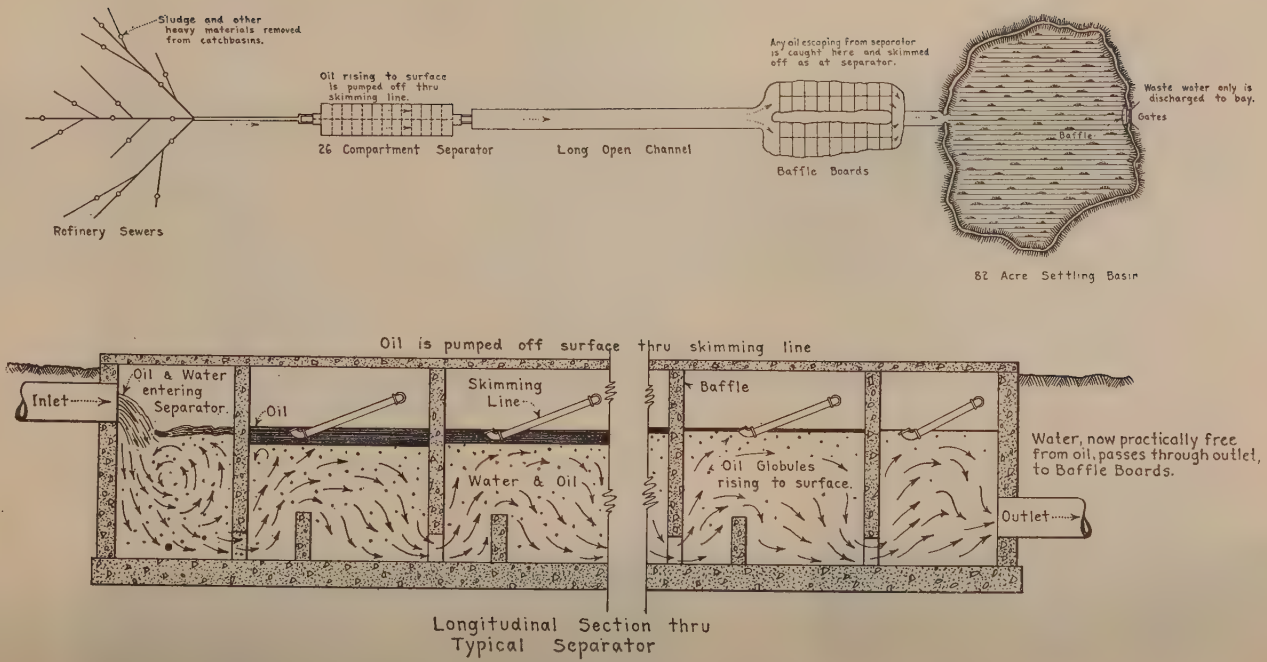
Sludge and other heavy materials removed from catchbasins.
Refinery Sewers
Oil rising to surface is pumped off thru skimming line.
26 Compartment Separator
Long Open Channel
Any oil escaping from separator is caught here and skimmed off as at separator.
Baffle Boards
Waste water only is discharged to bay.
Gates
Baffle
82 Acre Settling Basin
Oil is pumped off surface thru skimming line
Inlet
Oil & Water entering Separator.
Oil
Skimming Line
Water & Oil
Baffle
Oil Globules rising to surface.
Water, now practically free from oil, passes through outlet, to Baffle Boards.
Outlet
Longitudinal Section thru Typical Separator

FIG. 58. Diagram of an oil separating system. Courtesy Standard Oil Company.

FIG. 59. This oil sump was a death trap for many birds.

FIG. 60. Boom for surrounding and controlling an oil spill.

A simple device installed at many marine terminals, ready for immediate use to localize and control a spill, is shown in figure 60. This boom can be rapidly brought into use from the rack to encircle a spill. Straw can then be placed on the oil, as shown in figure 61, after which the straw with the adhering oil can be raked together and burned. In a similar manner straw may be utilized for the clean up of an oil covered beach as shown in figure 62. In the event of a larger spill the main harbors have ship service companies equipped with suction pumps and separators on a barge for effecting a satisfactory clean up.

Fig. 61. Straw being used to clean oil spill on water.

In figure 63 you will note the drip pans now almost universally installed beneath terminal valves to prevent water contamination. In addition, the larger terminals are equipped with a ballast line for the purpose of conveying oily ballast water to adequate separators before discharge to State waters.

A cooperative plan in which concrete evidence and immediate action can be taken when oil is discharged in violation of Section 481 was initiated about two years ago and is being expanded rapidly. This plan includes harbor and coastal patrol by the Coast Guard and State, and provides for immediate reports from U. S. Customs officers. Arrangement for rapid action through the courts prevents undue holding of a ship in port. Essential evidence includes samples of oil from the ship or other source and from the water or beach; pictures indicating sampling locations and existing conditions, together with statements of witnesses of the violation. In many cases, analyses of samples, with data on tides, winds, currents, etc., forge an additional link in the chain of evidence. The attitude of the offender and his efforts to correct the condition or make

a cleanup are given considerable weight, and in some instances the violation may be prosecuted in Federal court.

While the term "factory refuse" includes waste from a hundred and one different plants that may be deleterious, objectionable or prohibitive in various ways, it seems desirable to mention a few problems under this general term due to the wording of Section 481.

In one instance where a fish cannery discharged large quantities of visible solids and sludge forming material, our efforts to secure a remedy resulted in the installation of a specially designed rotary screen which not only rectified a deplorable condition, as may be noted from figures 64 and 65 taken before and after this was effected, but also resulted in the plant recovering valuable products, formerly lost, which soon paid for the entire installation. Other plants are now putting in similar equipment.

Fig. 62. Straw being used to clean oil spill on beach.

Wastes containing sludge forming material are extremely deleterious due to gas formation during decomposition, change of bottom environment, and reduction of available oxygen. A water area in which this condition exists is pictured in figure 66. The masses of sludge which are being continuously buoyed to the surface through the accumulation of decomposition gases may be seen in this picture. Here again, analysis indicates that the waste contains appreciable quantities of valuable material, and steps are now under way to remedy the situation.

Many times a waste disposal, such as that from the milk plant shown in figure 67 will be practically invisible when discharged into State waters, but at some point down stream, perhaps several miles below the outlet, the resulting oxygen depletion may establish a complete barrier to fish migrating up or down stream. Figure 68 indicates a gravel filtration area installed at one such plant. Along the Eel River where dairy wastes were a major pollution factor, several

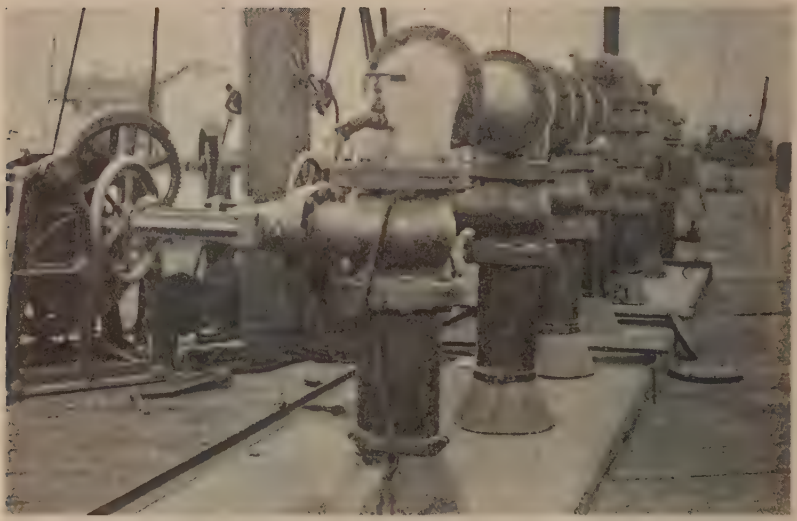

FIG. 63. Drip pans installed below valves to prevent leakage into the water from oil loading dock.

FIG. 64. Factory refuse on water.

FIG. 65. Clean water at same factory after installation of rotary screen.

FIG. 66. Patches of sludge brought to surface by fermentation gases.

measures, including distribution on alfalfa fields, installation of traps to collect entrained vapors from whey evaporators, and other devices, were responsible for greatly improved fishing and aquatic conditions in this well known salmon and steelhead stream.

The waste disposal from wineries in certain areas of the State has resulted in similar polluted conditions, producing heavy growths of objectionable fungus, destroying fish life, and establishing barriers from decreased oxygen at points forty miles down stream from the source of pollution. Detailed studies led to a restricting order which resulted in the California Wine Institute launching a program to find adequate methods of disposal or purification, and during the 1937 season, at least four different types of experimental treatment will be in operation. Whether any products of value to the industry will be recovered is yet to be determined. Figure 69 shows an area utilized for land disposal of winery wastes, but failure to maintain adequate dykes caused breakage, allowing the waste to flow into and pollute a nearby stream.

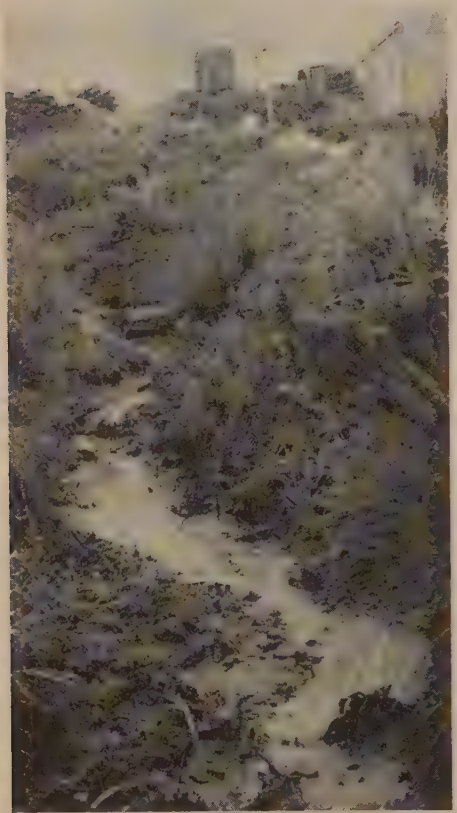

FIG. 67. Waste discharged from a milk plant.

One problem of factory refuse which has not as yet been given the attention it deserves is that from the fruit and vegetable canneries. The condition of one inland stream during the asparagus season may be noted in figure 70. Along a similar line, let us draw your attention for a moment to the thoughtless habits we encounter with respect to the disposal of domestic garbage, where, as noted in figure 71, this refuse after deposit in coastal waters has been carried by tides and currents to the beach. This brings to mind Webster's definition for the word "unclean," meaning "dirt out of place." We realize that garbage may be termed a necessary by-product of civilization, but, like a cow on a dance floor, is decidedly out of place when deposited in State waters. In this regard we sincerely solicit the unselfish cooperation of city, county and other officials to help solve this nuisance.

While the control over disposal of domestic sewage is largely in the hands of the Sanitary Engineering Bureau of the State Department

FIG. 68. Gravel bed installed for filtration of milk waste.

FIG. 69. Land disposal of winery waste. Note broken levee.

FIG. 70. A river covered with asparagus butts during cannery season. Photograph courtesy of *Sacramento Union*.

FIG. 71. Garbage on one of our ocean beaches.

of Public Health and local health districts, yet in several instances, improvements in disposal methods have been effected through our assistance. Marked progress in eliminating pollution from this source has been made in the past few years, but much yet remains to be accomplished.

It is generally conceded that the mining industry has been one of the chief factors in the upbuilding of this State, and, like other industries, it had its days of depression. However, it was one of the first to start back up the ladder and today many new mines are being operated and old ones are again active. In former days mining was conducted to a large extent in unfrequented mountain areas and the problem of damage to fish life was not forcibly brought before the public. The question of damage to ranchers from hydraulic mining

FIG. 72. A gold dredge.

debris is a well known chapter of California history, and this form of mining is now regulated to a certain extent through the California Debris Commission, a branch of the U. S. War Department, which has jurisdiction in so far as the debris may be deposited in navigable waters.

With the present boom in mining, and with new highways leading to all sections of the State, the question of handling waste water from mining operations is one of major importance and surveys indicate that more attention must be given each day to this industry which not only depends on natural resources but may also destroy others if permitted to operate without restriction.

In the Trinity and Klamath river area, Section 482 of the Fish and Game Code prohibits hydraulic mining and restricts other types of mining on the basis of river clarity from July 1 to November 30, the primary purpose of the law being to provide satisfactory fishing conditions during the run of salmon and steelhead. A dredger and a

gravel pit operation, typical of mines in this area that have been able to continue through the restricted season by impounding or filtering their waste water, are shown in figures 72 and 73.

Tailings from quartz mills and similar mines are particularly deleterious to fish life and may render a stream unfit for any normal use. In a number of areas, this material has been discharged into State waters without any attempt to clarify or settle out the pulver-

FIG. 73. Gold mining on a gravel bar.

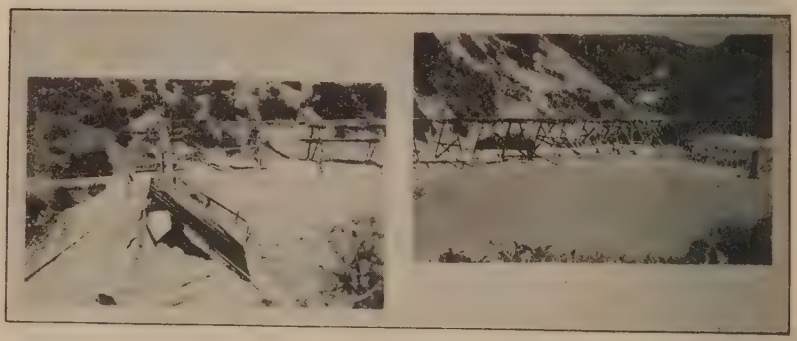

FIG. 74. One method of impounding mill tailings.

ized and spent ore which it contains. Active steps in all parts of the State where such conditions exist are being taken to remedy the situation. The impounding of mill tailings is a relatively simple and inexpensive procedure, for by proper distribution from a flume, the tailings can be partially utilized to form their own levee, as indicated in figure 74. However, the installation shown is not satisfactory, since the levee is directly below the flume and an overflow would result in break-

age, causing an avalanche of tailings and debris, sweeping all fish life with it, and covering stream bottoms to a considerable depth, thereby destroying aquatic organisms, the basic food supply of fish. Care in properly locating a tailings pond so that storm waters will not flush it out, and care in maintaining it in such a way that the high point of the levee is well outside of the distributing system are essential necessities. Figure 75 indicates a tailings pond that has not been adequately protected. Figure 76 shows a stream into which mill tailings have been allowed to flow and you will note the extent to which the rocks are covered and the general slimy appearance of the water.

FIG. 75. Poorly impounded mill tailings.

In many instances the waste water from mining shafts or mill operations may contain acid, metallic salts or other chemicals which are extremely poisonous to aquatic life. Copper and zinc may be mentioned as two such elements which must be rigidly controlled to prevent contamination of streams. Recently a mine which had not been operated for a number of years was reopened and the first procedure consisted of pumping out the tunnel shaft. The chemicals contained in this water were so poisonous that fish were killed for a distance of 60 miles downstream. Obviously, immediate action was necessary in this case and operations at the mine were closed down until proper measures were taken to safeguard the stream against further contamination. Figure 77 shows dead fish resulting from such a catastrophe. However, as with certain other industries there appears to be a tendency toward regulating their own group in an effort to prevent damage to natural resources.

FIG. 76. A fine stream ruined by mill tailings.

FIG. 77. Dead fish from polluted water.

From time to time the streams in our timber country become contaminated with sawdust or other sawmill refuse. The placing of such material in State waters or depositing it where it can get into State waters is strictly prohibited and the necessary action is strictly a matter of law enforcement. Sawdust is deleterious to fish life both from the standpoint of poisonous substances extracted by the action of water and also through irritation and damage to the gills by mechanical action. Figure 78 shows where sawdust had been deposited in a gulch close to a

fishing stream into which it would be washed by the first rain. At the time this picture was taken an attempt was being made to burn up the sawdust as indicated by the smoke in the picture. An overhead conveyor which had been installed at our request to keep sawdust out of the channel may also be noted.

FIG. 78. Sawdust deposited in stream bed.

Additional types of pollution might be described, but we believe that the foregoing is sufficient to indicate that control over pollution of State waters is an ever present problem that will require continuous and vigorous attention as population and industry continue to grow. In attaining the goal of preserving fish, game and other natural resources for the benefit and enjoyment of present and future generations, we do not in any way want to place an undue burden on any private enterprise, but conversely, private enterprise should not place an undue burden on the people of the State.

In conclusion, we would like to thank publicly those agencies who have so willingly cooperated with us, and in particular the U. S. Coast Guard and U. S. Customs.

NOTES ON THE DEER OF CALIFORNIA REDWOOD STATE PARK [1]

By Robert T. Orr,
California Academy of Sciences

During the late spring and summer of 1935 considerable opportunity was afforded to make observations on the life history of the Columbian black-tailed deer, *Odocoileus hemionus columbianus,* in California Redwood State Park. While most of these observations were made with the practical purpose in mind of arriving at some satisfactory solution concerning joint occupancy of this recreational area by man and native species, such as deer, certain interesting features in connection with the natural history of the latter were obtained. Deer, particularly, are of such economic importance as game and vary so much in habits, geographically, that there always appears to be justification for adding further to our knowledge of their behavior.

The California Redwood Park is one of the largest State parks in California, composed of approximately ten thousand acres of land situated in the west-central part of the Santa Cruz Mountains. The area, in general, includes the greater portion of those western-flowing drainage systems which are naturally limited to the north and south by Butano Ridge and Ben Lomond Mountain, respectively.

The floral composition of the Park varies to a considerable extent. There are extensive tracts of redwood forest, woodlands, some cut-over areas and a large number of arid, rocky, chaparral-clothed ridges. Deer were found to be most abundant in oak-madrone woodlands where there was a fair amount of underbrush combined with small clearings. Chaparral-covered slopes and burned-over land where second growth timber and invading brush types were present likewise offered favorable habitat for members of this species. The redwood forested canyons proved to be the least desirable cover for deer, although in the central camping area in Big Basin, deer were found to be present in numbers, having been attracted there as a result of artificial feeding.

A conservative estimate made by the writer in regard to the number of deer present in the park was 250. This is equivalent to 16 deer per square mile or one for every 40 acres. This figure was obtained during June, 1935, by careful and repeated counts on a number of sample areas, including various habitats. Only adults and yearlings were taken into account. Young of the year were not included; consequently this represents the lowest ebb in the annual population. Furthermore, as certain portions of the park were far more favorable for deer than others the number of deer per square mile in such areas was considerably greater than in other less suitable situations.

[1] Submitted for publication, July, 1937.

Throughout the spring and summer months the following plants were found to be most important as food for deer: canyon oak (*Quercus chrysolepis*), California lilac (*Ceanothus thrysiflorus*), *Ceanothus papillosus,* buck-brush (*Ceanothus cuneatus*), salal (*Gaultheria shallon*), huckleberry (*Vaccinium ovatum*), madrone flowers (*Arbutus menziesii*) and various edible grasses.

Canyon oak and grasses, when available, were selected in preference to all other types of vegetation. In places where the canyon oaks were well trimmed up from browsing it was not uncommon to see deer standing on their hind legs in order to reach the lower limbs. On chaparral slopes buck-brush was of next choice, whereas in and around the redwood forest and especially where there was a second growth forest, *Ceanothus papillosus* and *Ceanothus thrysiflorus* were also important food plants. Salal and huckleberry appeared to be

FIG. 79. Deer attracted to a feeding table at Governor's Camp, California Redwood State Park. Photograph taken in spring, 1936, published through courtesy of the U. S. National Park Service.

less desirable for food. They were chosen as a rule when other more palatable species were lacking.

Where grassy clearings or meadows were present, small groups of deer were found to congregate during the early morning and evening feeding hours. The size of these groups varied from two or three individuals in small clearings, as in burned-over land, to as many as 15 in natural meadows 150 yards or more in diameter. The brush surrounding these grasslands was browsed much more heavily than elsewhere. This was accounted for by the fact that the deer fed for some time on this brush, both before coming out into the open and again after the period of feeding on grass was completed. Likewise, individuals were seen to leave the grassland occasionally for short periods of time to browse on the nearby brush and lower limbs of oaks.

Most of the young are born in this region between the middle of May and the end of June. On May 22, 1935, the first fawn of the year was reported as seen, and from this date on they were noted

daily in increasing numbers. By the end of June the writer estimated that approximately 80 per cent of the does had borne young. Twins were found to occur in about 20 to 30 per cent of the cases.

Due to the protection afforded deer in California Redwood State Park and the attempt made on the part of park authorities and visitors to cultivate their friendship, there is practically no sign of fear exhibited toward man by these animals in this region. This statement does not apply, however, to young of the year. For a number of weeks after birth the young of relatively tame parents showed a very definite fear and distrust of people. While the mothers would feed out of one's hand, the young at this early stage would stand a considerable distance away and at the slightest provocation dash off in a series of jumps to the nearest brush. This behavior seemed to indicate that fear of man is a natural instinct which must be overcome in these animals rather than a fear developed through the life of the individual due to unfortunate contacts with the human species. Yearlings, which were often seen following does before the latter gave birth to young of the year and even to some extent after, were as tame as adults.

The only times that voice was recorded was when does were attempting to call their fawns. On such occasions they were heard to give a low bleat, not unlike that of a sheep.

The reaction between deer and raccoons in the camp grounds at night, particularly around garbage containers, presented some rather interesting aspects. As both these species are relatively common here and have equally developed a relish for certain types of food deposited in garbage cans, they frequently come into conflict with each other. Repeated observations made at night by the writer at these points of controversy showed a mutual feeling of distrust to exist between members of these two species. The deer, when disturbed by raccoons, would continually attempt to strike the intruders with their fore feet, and would not eat if any of the smaller animals were close behind them. The latter also distrusted the deer and often tried to nip their heels. The deer being the larger were more often the victors. Three or four raccoons, however, frequently so disturbed a deer that it would go away and leave the food to the former.

The custom on the part of park officials at Governor's Camp of supplying deer with food daily has been carried on over a good many years, resulting in the accumulation of a band of tame deer which are to be found in or close to the camp all year around. The effect of this has been both good and bad.

Visitors, especially those who are casually driving through the park or who stay for the day, are usually thrilled at the opportunity of approaching close to these creatures of the wild and having them take food out of their hands. Observation at such close range is likewise educational, both to adults and to children, many of whom have their first view of this species at the camp.

On the other hand, let us consider some of the detrimental effects that this artificially produced band has brought about. First, it is not true to nature. This fact must be borne in mind if we hope to make our parks into areas where all the component elements are preserved in or as nearly in their original state as is possible.

Under normal conditions deer would not be apt to congregate in the area where the camp is located, due to the presence of people, the denseness of the forest, and the scarcity of native food plants. The last mentioned point is of particular importance. The clearing in the camp center, around which most of the administrative buildings are now situated, was originally somewhat boggy in nature. Rushes and sedges, both of which are rather unpalatable to deer, formed the dominant vegetation. Very few canyon oaks occur in the surrounding redwood and Douglas fir forest and the situation is not suitable for the growth of *Ceanothus.* Hence, salal and huckleberry, two of the less desirable food plants, remain as the principal native types of food upon which deer must rely.

FIG. 80. A portion of the band of deer which constantly remains in the vicinity of Governor's Camp. Note how closely the grass has been cropped, although the sedge is largely untouched. Photograph taken in spring, 1936, published through courtesy of U. S. National Park Service.

The few canyon oaks which remain around Governor's Camp are well trimmed up and any young trees which now try to grow are eaten before they rise more than a few inches above the surface of the ground. This denuding effect on the vegetation, caused by an over-abundance of deer combined with the great concentration of people tramping over the region during the summer months, has caused a very serious depletion of the ground cover. Furthermore, it has made those deer, which stay constantly in this defined territory, dependent to a large extent upon the food which they are given by the Park officials and by campers and visitors. Since this food is of a wholly unnatural type and the native species of vegetation that deer feed upon are not those that are preferred, it is questionable as to the benefits derived from this practice. Experiences in our National Parks have shown that, invariably, disastrous results occur when man, with well meaning intentions, tries to direct the course of nature and cultivate too close a friendship with native wildlife.

SEVENTH ANNUAL BLACK BRANT CENSUS IN CALIFORNIA[1]

By James Moffit,
California Academy of Sciences

For the seventh consecutive year, counts of black brant, *Branta bernicla nigricans,* were made during February, 1937, on the bays along the California coast where the species is known to winter. As in previous years, censuses were taken in Bodega, Tomales and Drake's bays on February 10; but elsewhere, due to circumstances which prevented the members of the Division of Fish and Game from participating on this day, counts were not made until February 15. This year Game Warden Earl Caldwell, a new cooperator, took the census on Humboldt Bay, otherwise counts were made by observers who had participated in previous censuses. The cooperators are named under the reports for individual areas, and grateful acknowledgment is hereby made for their assistance.

HUMBOLDT BAY

Game Warden Caldwell, counting from a boat on this bay February 15, 1937, a clear calm day, secured what he considered to be an accurate census of the brant present on North and South Humboldt Bay, a total of 22,500 birds. Tides on the bay (South Jetty Landing) this day were as follows: low tide, 9.10 a.m., 0.6 ft.; high tide, 3.09 p.m., 5.1 ft.

This year's census total is less than half the number of brant found on Humboldt Bay, February 10, 1936. The writer made estimates of the brant present on Humboldt Bay, March 1 and 3, 1937, when he was convinced that at least 30,000 individuals, perhaps many more, were present. At this time conservatively 20,000 birds were found in the southeastern arm of South Bay, from Fields Landing to Table Bluff. Undetermined large numbers of others were seen, too distant to count, along the western shore of the bay, while 10,000 more were estimated present on North Humboldt Bay on these days.

These observations indicated that maximum brant concentration was not reached on Humboldt Bay until after the census date, February 15, 1937.

BODEGA BAY

J. M. Linsdale, University of California Museum of Vertebrate Zoology, counted the brant on Bodega Bay for the sixth consecutive year. The 1937 census was made on February 10 in the two hours preceding noon. A strong southeast wind made but little disturbance on the water and tended to concentrate the birds near the southeast shore where the observer found accurate counting practicable. Repeated counts gave totals of 1200 to 1400 birds in flocks, with enough

[1] Submitted for publication, August, 1937.

scattered individuals present to make the total on the bay approximately 1500 brant. The tides on this bay were essentially the same as recorded below for Tomales Bay.

TOMALES BAY

R. T. Orr, California Academy of Sciences, and the writer took the census on this bay from 9.30 a.m. to 1.30 p.m. of February 10, 1937. During the first two hours, the birds were feeding in a mass in the center of the bay north of Hog Island, where accurate counting was impossible. Later, as the tide receded and the southeast wind increased, most of the birds came close to or on shore, between Hamlet and Toms Point (see Fig. 73, Calif. Fish and Game, vol. 18, 1932, p. 301). Here, a satisfactory count was procured. Notable in this day's census, as contrasted with previous ones, was the almost complete absence of brant on the Outer Bay, north of Toms Point, where but five individuals were found. Sixty brant were found alongshore between Hamlet and Blake's Landing, a mile and a half south. Otherwise the birds were confined to the area between Hamlet and Toms Point. At the end of the census, 610 brant were counted, bird for bird, on the mud at the mouth of Walker Creek, just northeast of Hamlet. Some of these were less than 100 yards from the observers. The total for the census on this bay was 1556 brant; but a later report from Linsdale, who passed by Hamlet shortly after we finished counting, that he saw several hundred birds which had apparently flown in from the ocean alighting on the bay north of Hog Island, indicated that we may have missed some of the birds in our census. It is conceivable that these birds may have come from Bodega Bay, rather than from the ocean. We attempted to go out on the ocean in our small boat at noon time, but the strong wind and heavy seas prevented. We saw no brant on the ocean, which appeared to be too rough for them to rest upon in comfort, nor did we in the entire census period note a single flock of these birds crossing the bar between Tomales Bay and the ocean.

Tides at the entrance of Tomales Bay, February 10, 1937, were as follows: low tide, 4.15 a.m., 2.4 ft.; high tide, 11.53 a.m., 5.0 ft.

DRAKE'S BAY

Game Warden Bert Laws counted the brant on this bay from daylight, 6.30 a.m., to 7.30 a.m. of February 10, 1937. He found the surface of the bay rough from a fresh southeast wind and the birds scattered in open water. Before it was light enough to start counting, Laws noted several flocks of from 50 to 75 brant rise, circle and head northwest, presumably going to the ocean or to Tomales Bay. His count indicated that after these had left, there were approximately 1500 brant remaining on the bay. If the brant that departed before daylight from Drake's Bay went to Tomales or Bodega bays, they were included in the censuses for those points, since same were not commenced until later in the morning. Tides on this bay were of essentially the same range as, but 45 minutes earlier than, recorded above for Tomales Bay.

J. E. Cushing, Jr., who took the 1936 census on this bay, was unable to do so on the appointed date this year, but he counted the

brant on Drake's Bay, February 15, 1937. This was a clear day with north wind. The tide was 4.4 ft. high at 2.45 p.m. and the count was made from noon until 3.00 p.m. The result, 2579 brant, is of interest in comparison with Laws' much smaller total secured five days earlier. It tends further to indicate that the numbers of brant fluctuate widely on Drake's, Bodega and Tomales bays, due, no doubt, to their interchange among the bays, and again emphasizes the necessity for making coincident censuses in this area.

MORRO BAY

The census at this locality was taken by A. P. Marshall and Game Warden F. W. Hecker, both of San Luis Obispo, on February 15, 1937. Weather conditions were ideal for the undertaking and the bay was quite smooth. The count was made after a low tide of 0.7 ft. at 7.30 a.m., from a vantage point on shore with the aid of binoculars. Each observer counted independently. Marshall's total was 5352 birds and Hecker's was 5331. The close agreement of the tallies confirms these observers' conclusion that they were able to secure exceptionally accurate counts by reason of the birds' scattered, yet undisturbed, positions over the bay. For sake of conservatism, Hecker's lesser total of 5331 birds is used for the 1937 census at Morro Bay.

After completing the count at noon, the cooperators went north along the coast, past Cayucos, Cambria, San Simeon and Piedras Blancas to Arroyo Cruz, looking on the way for brant in the off-shore kelp beds. Thirty-five birds were found close to shore, midway between San Simeon and Piedras Blancas; no others were seen.

MISSION AND SAN DIEGO BAYS

L. M. Huey, San Diego Natural History Museum, who has made four of the six previous brant counts on these bays, once more cooperated this year, with the assistance of Game Warden E. H. Glidden of San Diego. The census was made from 10.00 a.m. to 1.30 p.m. of February 15; during this interval, the tide was high at 4.2 ft. at 11.56 a.m.

Although it was found impossible to make bird for bird counts, both observers agreed that their estimates, as here provided, represented very conservative ones for the birds present this day. On Mission Bay, 450 brant were found in three groups, one to the east and two to the west of the Causeway. Between Santa Fe and Cottonseed points, on the east side of San Diego Bay near the mouth of Sweetwater River, a group of 350 brant were found. This total, 800 birds for the two bays, far exceeds the highest of any of the previous censuses (161 brant were counted on both bays in 1934). It is especially encouraging, because observations by Glidden previous to the 1937 census, indicated that the birds were established on San Diego Bay for some time. Glidden advised me by letter dated January 22, 1937, that on the afternoon of January 20, he found approximately 800 brant near the old cottonseed plant on the east side of San Diego Bay. The following morning at daybreak, 280 brant were found in the same locality, where more arrived in small groups, until by 9.30 a.m., when Glidden had to leave, 325 birds were assembled.

These observations tend to indicate a regular repopulation of San Diego Bay in the spring of 1937, by a relatively large number of brant. The occurrence is most gratifying and it is to be hoped that the birds will return next year. A number of years ago, the bay was the winter rendezvous for thousands of brant, but it has been many years since so many individuals have been recorded from this area as in 1937. In recent years, brant have appeared on San Diego Bay only sporadically, in small numbers, and did not remain for long. These groups probably represented migrating birds. The fact that about 800 brant apparently occupied this and Mission Bay for a period of nearly a month, possibly longer, is decidedly encouraging for the successful reestablishment of the species as a regular winter sojourner to the area.

TABLE I

Recapitulation of the California Black Brant Census, 1931–1937

Locality	1931	1932	1933	1934	1935	1936	1937
Humboldt Bay	Unsatisfactory	29,415	5,000	16,860	115,000	50,000	22,500
Bodega Bay	None made	3,200	977	1,298	3,700	350	1,500
Tomales Bay	9,445	6,285	7,409	5,565	6,850	9,175	1,556
Drakes Bay	None made	2,108	318	2,189	1,995	1,500	1,500
Morro Bay	4,493	2,938	None made	3,895	7,544	5,000	5,331
Mission Bay	71	No birds	115	154	9	30	450
San Diego Bay	No birds	No birds	No birds	7	55	No birds	350
Totals	Incomplete	43,846	13,819	29,968	135,153	66,055	32,187

NOTES ON THE 1936-1937 BRANT FLIGHT

Observations, other than those previously provided under the census report for the area, are lacking as regards the brant migration at Humboldt Bay.

On a visit to Tomales Bay, November 1, 1936, no brant were seen in a careful search of the bay and adjacent ocean, nor did local residents report having noted the species, as yet. Returning to the locality on November 26, I estimated upward of 2000 brant present. These, local residents stated, commenced to arrive on November 15. No birds were noted prior to this date, when large numbers appeared and arrivals continued over three days until about 2000 birds were present.

On December 22, 1936, I estimated that there was approximately the same number of birds on the bay as in late November. By January 21, 1937, the brant population on Tomales Bay had increased to an estimated 3000 birds. It is to be noted that this total fell off by census time, February 10, to half that number of birds, and scarcely more than 2000 brant could have been on the bay at the time of a visit on March 14.

Three black brant, perhaps crippled or oil-incapacitated birds, were noted on Tomales Bay just north of Hamlet on June 25, 1937. These individuals appeared healthy and could fly well. The occurrence presents an exceptionally late spring record for the region.

Reports from Morro Bay, made by A. Silva, long time resident and brant hunter in this locality, kindly transmitted to me by Nathan Moran of San Francisco, indicated that the first brant was noted there in the autumn of 1936, on November 16. By November 28, the birds were abundant on the bay. No numerical estimate was made by Moran,

who hunted on this and the following day, but there were at least many hundreds of brant present and he had no difficulty in shooting the limit each day. As a matter of interest, tending to indicate the longevity of geese, is Silva's statement to Moran that he had observed presumably the same, peculiarly marked, albinistic brant on Morro Bay each winter for 23 years. The bird was killed there last November. If this was indeed the same individual, which seems quite probable, since reports of albinistic brant are few, it is of further interest in that it indicates that the same individuals tend to winter in the same locality year after year.

D. D. McLean, Economic Biologist, Division of Fish and Game, San Francisco, reported seeing a flock of from 150 to 175 brant flying south, over the ocean about a quarter mile offshore, near Oceanside, San Diego County. If these were migrating birds, their direction of flight was contrary to the usual one at this season when most brant noted off the California coast are seen to be working northward. Possibly the group McLean noted were part of the San Diego Bay assemblage, returning to that place from a visit to the ocean to the north.

Richard S. Croker, of the California State Fisheries Laboratory, kindly provided for use in this report, the following note concerning a seemingly seasonally late record for the species to be found in numbers in Lower California, as follows:

"On April 20, 1937, our boat *Bluefin* was at San Quentin Bay, Lower California. D. H. Fry, Jr., of the Laboratory staff, who was in charge of the research work on the trip, reported seeing brant in the Bay. The brant were not counted but there seemed to be considerable numbers present. In the words of Fry, 'there were certainly hundreds and perhaps thousands, but I would hesitate to estimate their numbers as we visited only a small portion of the Bay.' Fry was accompanied by John F. Janssen, Jr., and Richard B. Tibby, also of the Laboratory staff. San Quentin was the only bay visited during the course of this trip."

It should be observed that the above date, April 20, is about the time that the main aggregations of brant leave California bays for the breeding grounds. After late April, it is unusual to find numbers of brant on any California bay. In view of this fact the Lower California record is judged to probably be unusually late for quantities of birds. Perhaps brant remained later than usual in Lower California waters in the spring of 1937, possibly held there by an exceptionally abundant food supply. If this were the case, it would account for the late arrival of the birds at Humboldt Bay and for the failure of the usual January and February increase in numbers on Tomales Bay, providing that the theory advanced in previous reports, on the strength of considerable evidence, that our spring brant increase comes to us from the south, is correct.

SUMMARY

The 1937 census of black brant in California in mid-February indicated fewer birds present than in the two previous years and in 1932, but more than in 1933 and 1934. The greatest loss, numerically, over the 1935 and 1936 counts, was at Humboldt Bay. This, our northernmost brant bay, has been shown by the previous censuses to be the locality where maximum seasonal abundance is attained latest and it is

also here that the greatest fluctuations occur from year to year. In point of percentage of loss in 1937 over the previous year, Tomales Bay showed the greatest drop with only 1,556 birds against 9,175 in 1936; approximately one-sixth as many individuals, or a loss of about 83 per cent over the previous census. This year's total for Tomales Bay is over three times smaller than the lowest previous count, in 1934. Counts on the nearby Bodega and Drake's bays were about average, so can not help to make up for the deficiency of birds on Tomales Bay. Food (eel grass) appeared to be as abundant as usual in this bay. The Morro Bay total was about average and close to last year's. The exceptionally large number of brant, apparently established for some time, on Mission and San Diego bays, was a matter of much interest.

A seasonally late report of numbers of brant on a Lower California bay and lateness of the usual January and February northward flights to Tomales and Humboldt bays, may signify that brant remained in Lower California later in the spring of 1937 than in normal years.

Again, I would like to emphasize the importance of a thorough understanding of the manner of occurrence of brant in Lower California, before we can properly interpret their exceptional numerical fluctuations to the north.

THE CHANGING ABUNDANCE OF THE PACIFIC MACKEREL, *PNEUMATOPHORUS DIEGO* A PRELIMINARY BOAT CATCH STUDY [1]

By Donald H. Fry, Jr.
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Division of Fish and Game

This paper is divided into two parts: Part I gives the results of the study without going into the methods used in obtaining them, and Part II tells how the results were obtained. The second section is of necessity much more technical than Part I.

PART I

INTRODUCTION

At first glance it would seem that the total catch of any market fish would be an exceellent indication of its abundance, and that changes in the total catch, from year to year, would indicate changes in abundance. This would be true if the same number of boats fished with the same gear and the same amount of effort each year. Unfortunately that is something which never happens. The demand for a species may suddenly increase, more and more boats go into the fishery and the total catch keep rising, in spite of the fact that each *boat* is getting less and less fish as time goes on. Conversely many boats may desert one fish to go after another more expensive one and thus cause the total catch to decrease in spite of the fact that each boat which does stay is having excellent luck. From this, it is obvious that the catch per boat would be a much better indication of abundance than the total catch of all boats. To refine the method still further it is often advisable to use a selected group of boats, follow the catches of each boat from year to year, and make sure that none of the captains has thrown a figurative monkey wrench into the statistical machinery by doubling the number of set lines in daily use, by changing from a five-man hook and line crew to a 10- or 11-man purse seine crew or by any of a dozen or more similar things.

It is also necessary to make sure that the demand for the fish in question is great enough so that the boats are landing all they can *catch*. If the demand is so limited that the boats are merely bringing in all they can *sell*, it is obvious that the fluctuations in boat catch are going to indicate the market demand rather than the abundance of fish.

[1] Submitted for publication, September, 1937.

THE BOAT CATCH CURVE

In calculating the boat catch curve for the Pacific mackerel, a selected group of boats was used. All were purse seine and ring net boats which fished for the Los Angeles and Long Beach canneries. Only at these canneries was the demand great enough so that boats of any kind could sell all the mackerel they could catch, and only the purse seiners and ring netters fished at all consistently for the canneries. Confining the study to Los Angeles and Long Beach may seem like an undue limitation. Actually it is not, since this one small region accounts for over three-quarters of the mackerel landed on the entire Pacific Coast of North America.

The catch curve covers the four years from 1933 through 1936. It has only been since 1933 that even the cannery demand has been great enough so that the boat catches would reflect anything but market conditions.

Let us examine this boat catch curve (Fig. 81) and see what it has done in the course of four years of practically unlimited demand.

1933

Most of the boats used in compiling this curve did their first heavy mackerel fishing in 1933, and learned the game during that year. For that reason the 1933 figures are not comparable with the later ones. Had the crews been experienced in 1933, their catches would undoubtedly have been higher, but we have no way of knowing how much higher.

1934

During 1934 the boats caught more than in the previous season, consequently both the boat catch curve and the total landings show a marked rise (compare Figs. 81 and 82). The boats had their best fishing in this year.

1935

In 1935 increasing numbers of boats and increasing size of boats forced the total landings up to an all-time high for the Pacific Coast, but the boat catch shows a decided drop from the previous year.

1936

The drop in the boat catch during 1936 was very bad. Even the total landings show a slump.

1937

The boat catch curve for 1937 can not be calculated until the season is ended, but the total landings to date (September 1, 1937) are far below those for the corresponding part of any year since 1933 and all along the waterfront one hears complaints about the scarcity of mackerel; in fact, fishing is so poor that many boats are deserting the mackerel fishery and going after other species.

Note added December 22, 1937: The 1937 boat catch was under 42 per cent of the 1935 value; the total catch for the year will be about 55 million pounds.

CONCLUSIONS

On a previous occasion[2] the writer has shown that the Pacific coast fishing grounds have been forced to produce far more mackerel than the much larger and very heavily fished grounds of our Atlantic coast. So intensely have the California grounds been fished that there has been every reason to look for a collapse of the fishery.

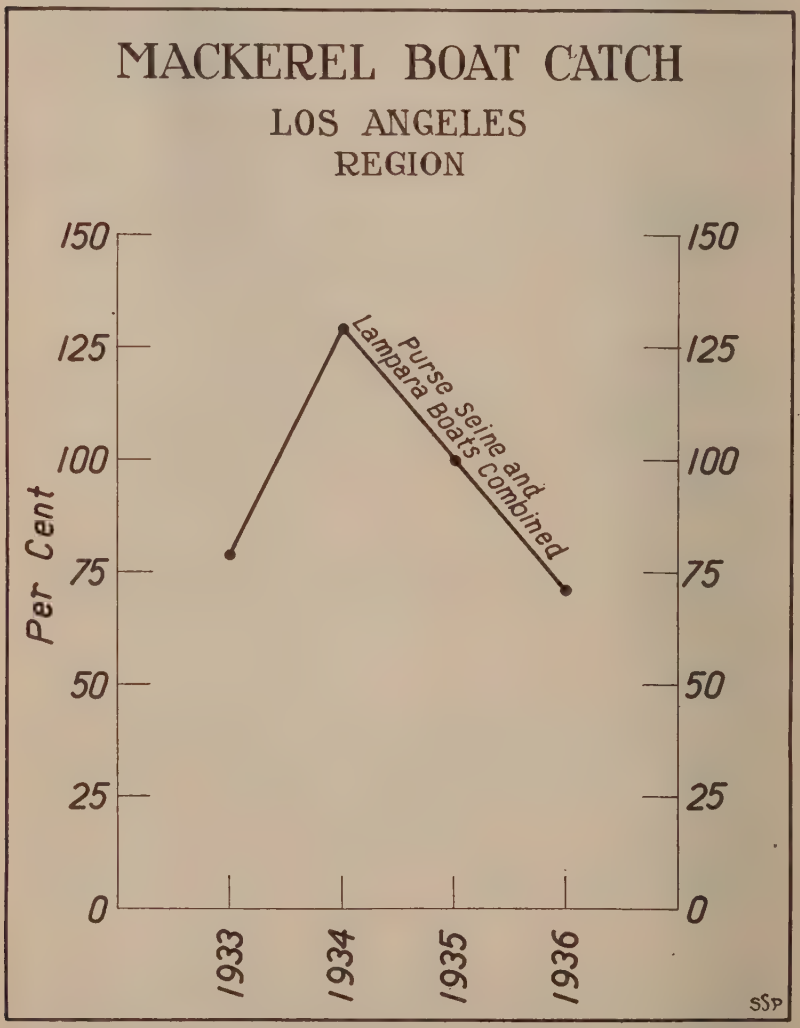


FIG. 81. Boat catches of the Pacific mackerel. Each year's catch is expressed as a per cent of the 1935 catch. The 1933 level is not comparable with the others, since most of the boat crews had to learn the business during that year and hence were not up to full efficiency.

[2] Mackerel catch is new Pacific Coast record. *California Conservationist*, vol. 1, no. 3, March, pp. 1, 20, 1936.

There seems no doubt whatever that in southern California the mackerel have been becoming steadily less abundant during the years since 1934. The only room for argument concerns the reason for this decline. One of the standard "reasons" given by fishermen for the disappearance of any species is that the fish are just as abundant as ever but have temporarily moved out of the fishing area. If the fish is an ocean species, this statement may be wholly or partly true. In any event, it is very hard to disprove. Four years' data are not

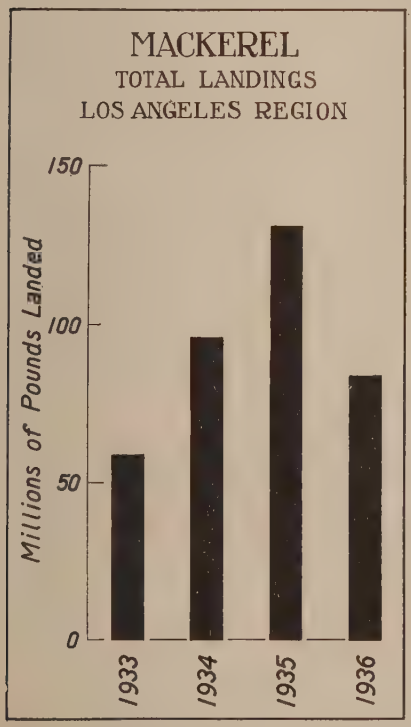


FIG. 82. Total landings of Pacific mackerel, Los Angeles region. This region takes over three-quarters of the mackerel landings of the entire Pacific Coast. An increasing number of boats kept the total landings on the up-grade until 1935, although the catch per boat had slipped during that year.

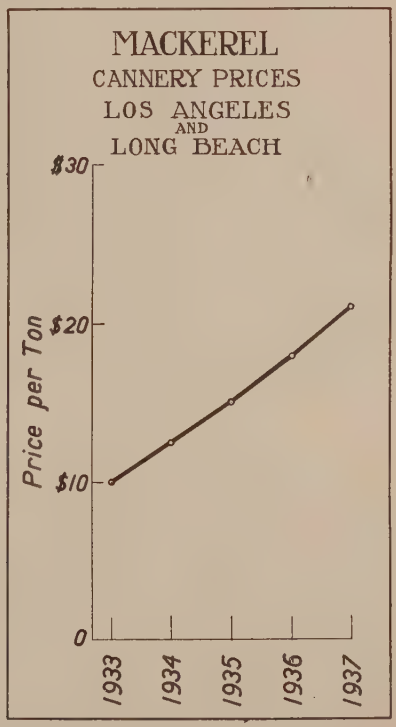


FIG. 83. Mackerel prices at the Los Angeles and Long Beach canneries from 1933 to 1937. The 1933 price of $10 per ton was raised to $12.50 about September 1 of that year.

enough to furnish such proof, but all the evidence we do have points to overfishing rather than natural fluctuations in a given area. Violent natural fluctuations tend to produce an irregular curve which jumps around without apparent rhyme or reason. The steady decline from 1934 to 1937 is far too regular. (The 1937 season is now nearly over and has been so poor to date that there is no doubt that both total catch and boat catch will be far below the 1936 level.) A gradual shift in population could cause this steady decline but the odds are against such a happening.

If we wait long enough to obtain absolute proof about the decline, and meanwhile fishing continues to fall off at the present rate, we will be arguing about a commercially extinct species. Whenever we take into account the intensity of fishing *and* the trend of the boat catch figures, it becomes evident that it is none too soon to adopt restrictive measures strong enough to allow the mackerel population to build up to a point where a reasonably large yearly crop can be taken.

PART II

SOURCE OF DATA

Whenever a commercial fisherman sells any part of his catch in California, the buyer is required by law to fill out in triplicate a special receipt on which are recorded the kinds of fish, the poundage and the price paid for each. The fisherman, the buyer and the California Division of Fish and Game each receive one copy of the receipt. The Division transfers the data from its receipt to special cards. Tabulating machines sort these cards and record the data from them in almost any desired form.[3] It is from special reports compiled by the operators of these machines that most of our boat catch figures are obtained. To back up these figures it is always necessary to do enough field work to obtain a fairly complete general knowledge of the fishery.

EFFECT OF DEMAND ON BOAT CATCH FIGURES

There are two nearly independent fisheries for mackerel in the State—for fresh fish markets and canneries. The fresh fish trade takes a small quantity of fish for local consumption. This fish must be carefully handled because mackerel bruise easily and when bruised do not keep well. The marketmen much prefer hook and line fish since the wholesale methods of the net boats effectively prevent careful handling. The canners on the other hand want large quantities of low-priced fish. The net boats meet this demand very nicely. To the packers bruised fish are not a serious consideration since they are in the can before they have had a chance to spoil.

As far back as our records go, the demand for mackerel at the fresh fish markets has been very limited—so limited in fact that the fishermen usually bring in only what they think they can sell. This limiting of catches makes a study of the landings of market boats absolutely useless for the detection of changes in abundance.

At the canneries the demand is much greater. The first large scale canning was done in 1928 and 1929, then came a three-year slump. All during these first five years the canners regulated the landings by sending the boats out on *limits*, i.e., they told each boat captain just how much they would buy from him. These limits were so low that the catch records from 1928 to 1932 are useless for the present purpose.

In 1933 all this changed. The packers had orders for canned mackerel, wanted fish badly, and took the lid off. It has been off ever

[3] Conner, Geraldine
1935. Modernizing commercial fisheries statistics. Calif. Div. Fish and Game, Fish Bull., no. 44, pp. 11-36, illus.
1937. Fish and game statistics. Calif. Fish and Game, vol. 23, no. 2, pp. 113-118.

since. A boat can sell all it can catch. From this it will be seen that the boat catches since 1933 are the only ones from which we can learn anything about abundance.

EFFECT OF PRICE

Demand and price are very closely related but should be taken up separately in this study. At the fresh fish markets, prices for one species often change by the hour and even by the minute. At the canneries, on the other hand, the price usually remains constant for an entire season. There may be penalties for small fish or poor fish, but the basic price changes very seldom. This constant price simplifies calculation immeasurably since there is no tendency for fishermen to stop work and wait for the price to rise while fishing is at its very best.

Entirely aside from the complexities caused by violently fluctuating prices, there is the effect of a steady rise or fall in price. A rise will tend to make fishermen pursue a species with more enthusiasm and to make more fishermen go after that species. Thus if the species remains equally abundant, a price rise tends to increase the total catch and, to a lesser extent, the catch of each individual boat.

The cannery price of mackerel has been steadily rising. The 1933 season opened with a price of $10 a ton. About September 1, it rose to $12.50, held this level throughout the rest of 1933 and all of 1934, jumped to $15 before the 1935 season opened, to $18 a year later, and to $21 in 1937 (Fig. 83).

There is certainly nothing in this price trend which would cause fishermen to lose interest in mackerel.

SEASON

There is a period each year when mackerel are very scarce. Hook and line boats get a few, but as a rule the cannery net boats get none at all. This period ends some time in May and fishing starts with a rush. There is good fishing until about December, then the fish disappear, sometimes gradually, sometimes more suddenly. The real period of scarcity may start any time from mid-December to March, but usually begins in late December or some time in January. Except for one difficulty we could follow a boat through the entire season. This complexity is the sardine fishery, which lasts from November 1 to March 31, a legally restricted season. Many boats go out after either sardines or mackerel and take whichever they see first. Sardines, being more abundant, are the more usual victims. This cuts down the mackerel catch in a way which is dependent on the relative abundance of the two species, and on the distance the fishermen have to go to find either. To eliminate this complexity, we have included in our calculations only those catches made between May 1 and October 31.

PRELIMINARY SELECTION OF BOATS

Our preliminary list of boats included all the cannery net boats which fished at all consistently since 1933. The net boats used in the southern California mackerel fishery fall into two distinct classes—purse seiners and lampara boats. The purse seiners are deep, broad beamed boats, 60 to 90 feet long, with carrying capacities of 70 to per-

haps 200 tons. The lampara boats are shallow, narrow craft. Most of those engaged in cannery mackerel fishing are from 45 to 55 feet long and carry 20 to 50 tons in smooth weather. The carrying capacity of a lampara boat depends to a large extent on the optimism or foolhardiness of the crew. The boats are dropping into disuse now but in former years it was nothing unusual to see a lampara boat so heavily loaded that its stern deck was 18 inches or two feet under water. In the mackerel fishery the catch of a lampara boat is often limited by its capacity, but a purse seiner is much larger and is nearly always able to carry all the crew can catch. For that reason the two types of boats were kept entirely separate in compiling the boat catch records.

Both types of boats use much the same sort of gear in fishing mackerel. A purse seine boat carries either a purse seine or a ring net; the lampara boats carry only ring nets. The differences between the two forms of gear are slight; a ring net is nothing more or less than a light weight, high speed purse seine. Both nets are set in a circle around the fish, and then closed at the bottom by a "purse line" just as a laundry bag is closed by a draw string.

CATCH PER DAY, MONTH OR SEASON?

After obtaining our list of boats, the next step was to decide whether the best unit of fishing effort was the catch per day, per month or per season. In going over the data it soon became evident that there was an increasing tendency for the boats to pass up small schools of fish and scout longer for larger schools. This resulted in a decrease in the numbers of small catches and an increase in the number of days on which nothing at all was caught. The small catches all appear in the records but the blank days do not, hence a decreasing number of small catches was bound to raise the *apparent* daily average. Obviously the average catch per day could not possibly give a true picture of what was happening in the fishery.

The use of catch per month or per season would get around any difficulty due to blank days, but each introduces some difficulties of its own. Fishing is far better in some months than in others, and only a small part of the boats fished straight through the entire season. Clearly if a boat fished only the best part of the season its *average* monthly catch would be higher than if it fished the entire season, but its *season's* total would be lower, because it would otherwise have caught something during the poor months. The obvious thing to do was to use only those boats which fished straight through the season, but unfortunately there were not enough boats which did this. Another possibility was to compare May, 1933, with every other May; June, 1933, with every other June; and so on until we wound up with six boat catch curves instead of one. These six could then be averaged. We will probably try out this method before finishing with our boat catch study of the mackerel.

The method finally decided upon for this preliminary study was to use the catch per season and to make an allowance for the time during which any boat did not fish. This allowance took into account just how good fishing was when the boat in question was not fishing,

and just how well that boat performed when it *did* fish. More about this later.

INFLUENCE OF BOATS TEMPORARILY DESERTING THE FISHERY

Since it was not possible to use catch per day as a unit of effort, it became necessary to decide just when a boat was fishing mackerel and when it was not. If a boat lands mackerel on 21 days out of a month and lands nothing else it is quite obviously fishing for mackerel. If it lands eight catches of tuna, and nothing else, it is obviously *not* fishing for mackerel. But, if it lands eight catches of mackerel, eight of tuna and three of barracuda, just what is it fishing for?

During part or all of the period from May through October, purse seine and ring net boats fish for mackerel, horse mackerel, tuna, skipjack, bonito, barracuda, white sea-bass and yellowtail.[4]

Horse mackerel is not a complicating factor. The boats take this lower priced species incidentally while fishing mackerel. In most cases a horse mackerel catch is an indication that the boat was fishing for mackerel.

Tuna and skipjack bring much higher prices than mackerel. Many purse seiners make long trips into Mexican waters for these fish alone. Such boats are easily segregated and do not have to be considered here. Frequently tuna or skipjack appear in local waters. When that happens many mackerel boats desert the fishery entirely for a week or a month and go after the more expensive species. Other mackerel boats go out with an open mind and come back with whatever they see first. Some of these go to the best tuna grounds and catch mackerel incidentally, others stick more or less closely to mackerel fishing and gather in any tuna or skipjack that happen to appear.

Bonito are in between tuna and mackerel in price, size and habits. Compared with tuna they are much more apt to be found on the mackerel grounds and to be taken in the same haul with mackerel. Unlike tuna, the bonito is seldom the cause of a large number of boats suddenly deserting the mackerel fishery.

Barracuda, white sea-bass and yellowtail[5] are fresh fish market species. Only the barracuda is abundant enough ever to cause any wholesale desertions from the mackerel fishery—and most of those desertions do not last long. Some small boat gets 5 to 10 cents per pound when the barracuda first appear, the purse seine fleet descends on the schools with a rush, the price drops to a half cent, and everybody goes home mad.

FINAL SELECTION OF BOATS

To make the final selection of boats, each season was divided into months and the monthly record of each boat examined in minute detail. If a boat spent a month in mackerel fishing, it was placed on the list for that month. If during the next month it spent too much time tuna fishing, it was left entirely off that month's list, even though it did quite a bit of mackerel fishing. If the boat brought in horse

[4] Horse mackerel, *Trachurus symmetricus;* bluefin tuna, *Thunnus thynnus;* skipjack, *Katsuwonus pelamis;* bonito, *Sarda sp.;* barracuda, *Sphyraena argentea;* white sea-bass, *Cynoscion nobilis;* yellowtail, *Seriola dorsalis.*

[5] Yellowtail may legally be canned only if it is taken south of the Mexican border.

mackerel, it was treated exactly as if it had caught mackerel. This was done because in all probability the boat was actually looking for mackerel. However, horse mackerel catches were treated as mackerel only in deciding what the boat was fishing for, *not* in calculating its seasonal boat catch. Trifling catches of unusual species were entirely disregarded—obviously they were caught while the men were looking for something else. The basis for selection or rejection was as follows:

If a boat spent a week or more fishing for anything except mackerel it was rejected for that month.

If a boat brought in mackerel regularly throughout a month, but also brought in loads of other species it was accepted only if the number of mackerel catches was at least twice that of all others combined. Otherwise, it was assumed that the boat had spent too much time looking for other species, or had deliberately gone into an area where the chances of stumbling onto an expensive species were better than on the best mackerel grounds. When mackerel and other species were landed the same day, the load was treated as a mackerel catch if it was over half mackerel.

Occasionally mackerel disappear entirely or become very scarce for a short period. Whatever a boat did during such a period was disregarded.

The criteria just given were the ones on which most boats were accepted or rejected. Other rules were established but were applied less often and need not be discussed here.

None of the rules used were set up until each catch record of every boat had been examined. The criteria were then established to give the most satisfactory and uniform treatment for all boats and all seasons. All of these rules were intended to increase the uniformity of treatment of the data; they were not intended to increase the ease of handling the data.

WEIGHTING EACH BOAT TO A FULL SEASON

When we had obtained our final list of boats it became necessary to determine just how each month compared with the other months of any one season. This was done by selecting all the boats which fished every month of that one season, adding up all the May catches, all the June catches, and so on throughout the season. Then, each month's total was converted into a percentage of the entire season's total. This method was used whenever possible. In 1935 only one lampara boat fished in every month, and in 1936 no purse seiner fished every month. In 1935, the average catch of all the lampara boats was taken for each month (arithmetic mean) and the monthly percentages were calculated from that. In 1936 the same was done for purse seiners. A comparison of the results obtained by each of the two methods in other years showed no differences of importance.

After calculating the relative values of the different months the next step was to calculate what percentage of a full season each boat fished. Assume the monthly values for one season are as follows:

	Per cent
May	7
June	15
July	18
August	10
September	20
October	30
Season	100

Let us say a boat is on the list during July, September and October. During those months it fished 18 plus 20 plus 30, or 68 per cent of the season. To weight that boat to a full season, the sum of its July, September and October catches was multiplied by $\frac{100}{68}$. Only those boats which fished over 45 per cent of the season were used.

NUMBERS OF BOATS USED IN COMPILING THE BOAT CATCH CURVES

A total of 14 lampara boats and 27 purse seiners was left in the final list from which the boat catch curves were calculated. The number used each season is shown below.

	1933	*1934*	*1935*	*1936*
Lampara boats	14	14	7	0
Purse seiners	12	10	27	17

WEIGHTING TO A BASE YEAR

Only a few of the boats used fished every season. Many new purse seiners were built between 1933 and 1936. Those boats were larger and more efficient than the older boats. If the actual catches of the boats were averaged, the entry of the new boats would tend to raise the average for the later years. To give all the boats equal weight, the seasonal catch of each was expressed as a percentage of its 1935 catch. The 1935 season was used as a base because it was the only season during which all of the purse seiners fished.

The lampara boat catches were treated in the same way except that 1934 was used as a base year. The boat catch curves were calculated by taking the average (arithmetic mean) percentage for each season.

To make the lampara boat curve comparable to the purse seine curve, it was reweighted to make 1935 equal 100 per cent.[6]

COMPARISON BETWEEN THE CATCH TRENDS OF TWO TYPES OF BOATS

The two boat catch trends are quite similar except that the lampara curve is flatter (Fig. 84). Some part of this difference is undoubtedly due to the smaller size of the lampara boats. We do not know just how much of the discrepancy is due to this one factor—perhaps only a small fraction—perhaps all. The mackerel catches of lampara boats were often limited by their capacities. The better the fishing the

[6] Theoretically this should not be done unless geometric means are used, actually results obtained by use of the two methods differed so slightly that we decided to use the better known average in this paper.

greater the limiting effect, hence there tends to be less difference between a good year and a poor year than is the case with purse seiners, since the catches of these boats are seldom limited by their carrying capacities.

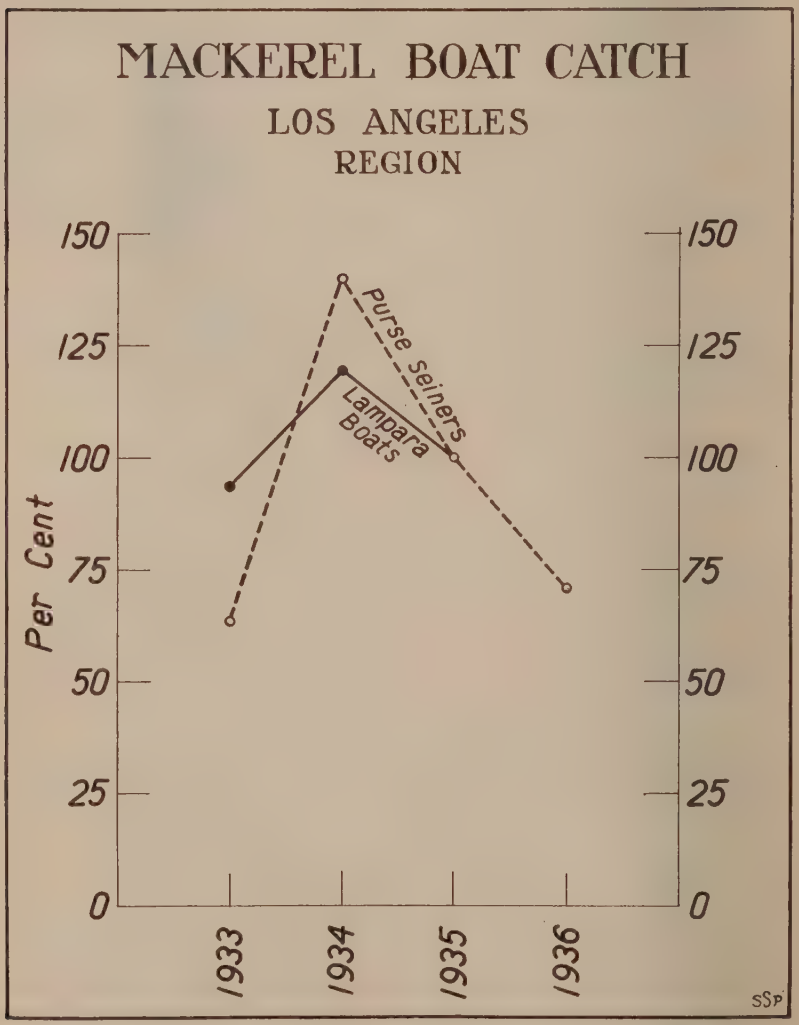


FIG. 84. Mackerel boat catch curves of purse seine and lampara boats. During 1936 no lampara boats fished consistently enough to be included in this study since many of the better lampara crews had bought or chartered purse seiners and tied up their old boats. The purse seiners are the ones more affected by changes in abundance. The reason: a purse seiner with a capacity of 100 tons may go out on a good day and catch 80 tons; on a poorer day it brings in 25 tons. A lampara boat with a capacity of 40 tons can not bring in over 40 tons no matter how good fishing is. On poorer days it may take as much as a purse seiner.

YIELD PER AREA OF THE CALIFORNIA SARDINE FISHING GROUNDS, 1935-1937 [1]

By Frances N. Clark
California State Fisheries Laboratory
Division of Fish and Game

An important addition to the study of any marine fishery is information about the yield of each water area. To know the locations of the most prolific fishing grounds constitutes an economic asset to the fisherman, an invaluable aid to the administrator, and a useful contribution to the science of oceanography. To accumulate this information for the fisheries of California, the California Division of Fish and Game has divided the waters of the coast into numbered blocks. Each block comprises ten minutes of latitude and ten of longitude. The fisherman, at the time that he delivers his load, is requested to report the number of the block in which he made his catch. For the sardine fishery this report is made to an assistant warden of the Division of Fish and Game or to the weighmaster at the cannery or reduction plant where delivery is made. This method of obtaining information about the locality of catch was instituted in 1934. By the 1935-36 sardine season the system was deemed sufficiently accurate to justify its use for an analysis of the yield taken per numbered block.

The results for the 1935-36 season were reported in 1937 [2] but are here repeated to make simple a comparison between the 1935-36 and 1936-37 seasons. The tons delivered during both seasons include the landings at shore plants only, and do not include deliveries made to floating reduction ships. Boats fishing for the floating ships make their catches in the same general areas as do the boats delivering to the shore plants but our detailed information about the locations of individual catches covers only deliveries made on shore.

The tons taken per numbered block are shown in figure 85 for the 1935-36 season and in figure 86 for 1936-37. As a whole the two seasons are similar, but they differ in minor details. In the San Francisco-Monterey area the deliveries were made either to San Francisco Bay ports or to the port of Monterey. In this area more tons were taken in the blocks adjacent to Pigeon Point, Point Montara and Point Reyes in 1936-37 than in 1935-36. This resulted in an increase in the total tons taken during 1936-37 in the entire San Francisco-Monterey area as the tonnages caught in other parts of the area changed but little between the two seasons.

In southern California, where our information comprises catches delivered to the ports of San Pedro and San Diego, the situation is somewhat different. In 1935-36 the fishery showed a strong tendency

[1] Submitted for publication, August, 1937. Credit for the drawing of figures 85 and 86 goes to Mr. Stevan S. Pavitt, of the Works Progress Administration, Project 6915-S, who also compiled the data for the 1936-1937 season from the detailed reports of the California Division of Fish and Game.

[2] Calif. Div. Fish and Game, Fish Bull., no. 48, 11 pp., 5 figs.

to concentrate in the blocks adjacent to Point Vicente, whereas in 1936-37 fishing was less concentrated and the greatest tonnages were taken in the block bordering on Newport. This represents an actual change in the location of the major fishing grounds. The total tonnage taken in the San Pedro-San Diego area was less in 1936-37 than in 1935-36.

Up to the present time no fishing for sardine canning and reduction plants has been carried on between Point Sur and Point Conception. This should not be construed, however, as an indication that sardines are not to be found in this region. This area lies too far distant to be profitably fished by boats operating out of the ports of Monterey or San Pedro. Also lack of suitable harbors and adequate labor and shipping facilities have prevented the establishment of large fishing centers along this portion of the coast. These factors and not the scarcity of fish or unfavorable fishing conditions apparently account for the absence of a sardine fishery in this area.

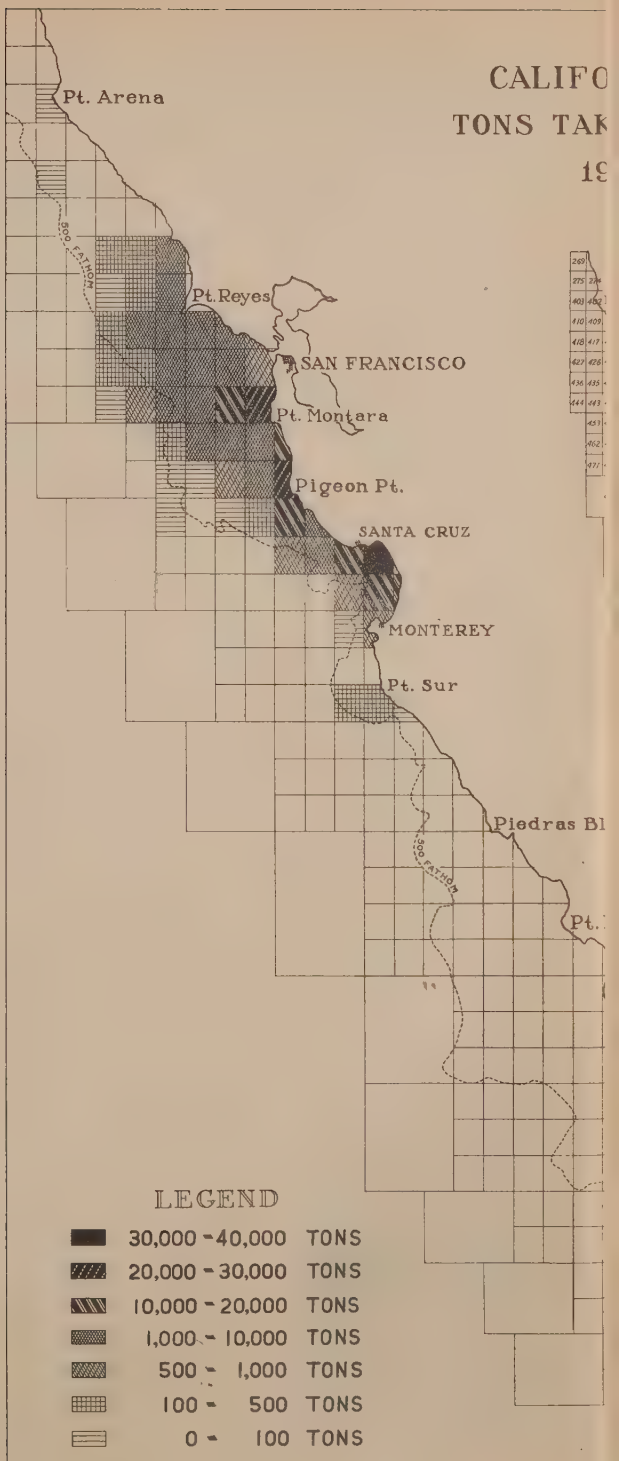
Along the entire coast there are very few records of catches made in waters deeper than 500 fathoms. In central California the fishing grounds extend northward and southward along the coast but not to great distances from shore. Near San Francisco the 500-fathom line lies well off shore and here the fishing grounds extend seaward in a corresponding manner. Southward toward Monterey Bay, as the 500-fathom line draws closer to land, the fishing localities are also limited to a similarly narrowing belt along the shore.

In southern California the ocean contours are more complex, but in this area also the fishing grounds are very largely confined to waters of less than 500 fathoms. Here comparatively shallow water extends out some distance beyond the Channel Islands, with the exception of a deep valley which runs southeast from Santa Cruz Island. Between San Nicolas and Santa Barbara islands it narrows and southeast of Santa Barbara Island divides. The two branches continue southeastward on either side of San Clemente Island. The fishermen cruise across this valley and fish beyond it but almost no catches are reported from squares lying wholly within the valley. This limitation of the sardine fishing grounds to comparatively shallow waters probably results from a corresponding distribution of the sardine population. Presumably sardine schools are not found over deeper waters, perhaps because food is more plentiful in the shallower regions. The complete explanation of this phenomenon, however, must await more detailed oceanographic investigations of the waters along the California coast.

To trace the history of the development of the California sardine fishing grounds is not possible from two seasons' data, but fortunately the California State Fisheries Laboratory has additional information about the localities where sardines have been caught in past seasons. Since 1919, members of the laboratory staff have questioned a limited number of fishermen each week and thus learned where the sardine fishing has been carried on year by year.

These records,[3] collected for nineteen years, all indicate that sardine fishing has occurred only within shallow waters. In the early history of the industry fishing was confined to waters very close to the

[3] Calif. Div. Fish and Game: Fish Bull., no. 11, pp. 128-130; Fish. Bull., no. 25, pp. 1-44; Fish Bull., no. 19, pp. 5-9; Fish Bull., no. 48, pp. 1-11.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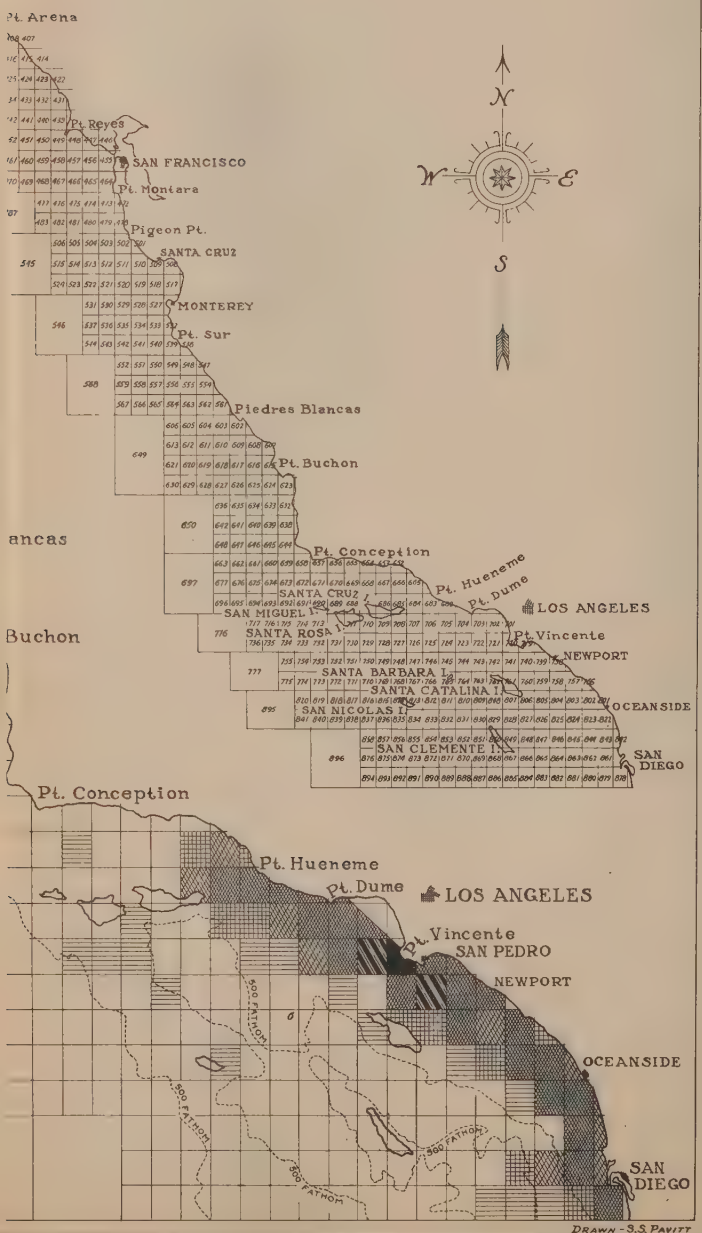
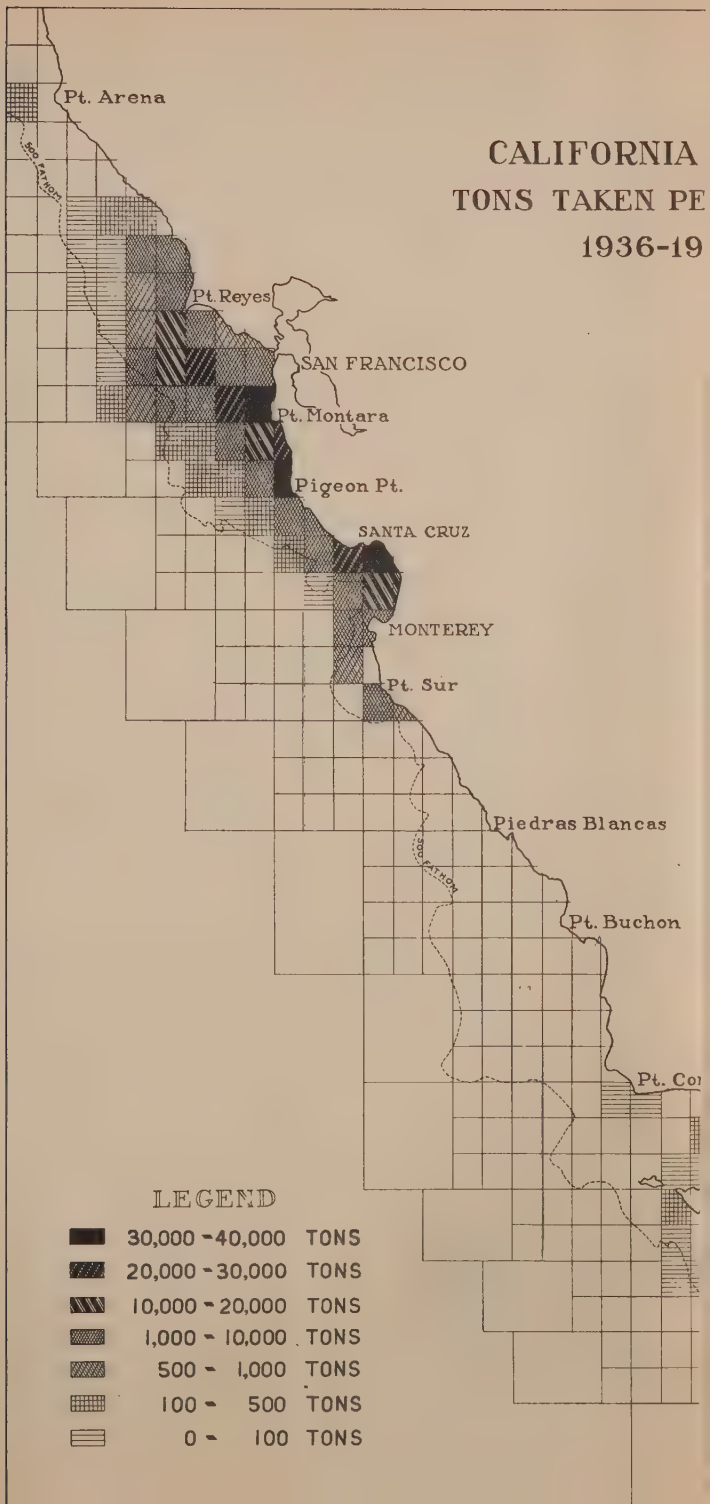
Pt. Montara
Pigeon Pt.
SANTA CRUZ
MONTEREY
Pt. Sur
Piedras Bl
100 FATHOM
Pt.
LEGEND
30,000 - 40,000 TONS
20,000 - 30,000 TONS
10,000 - 20,000 TONS
1,000 - 10,000 TONS
500 - 1,000 TONS
100 - 500 TONS
0 - 100 TONS

)RNIA SARDINE CATCH
:EN PER NUMBERED BLOCK
)35-1936 SEASON



DRAWN - S.S. PAVITT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Pt. Sur
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Pt. Buchon
Pt. Co
LEGEND
30,000 - 40,000 TONS
20,000 - 30,000 TONS
10,000 - 20,000 TONS
1,000 - 10,000 TONS
500 - 1,000 TONS
100 - 500 TONS
0 - 100 TONS

SARDINE CATCH
R NUMBERED BLOCK
37 SEASON

ports of Monterey, San Pedro and San Diego. As the industry grew and the demand for fish increased, larger boats were built and the fishermen cruised over wider areas. From Monterey the expansion was chiefly northward, with only a small number of boats occasionally cruising to the south. With the development of canning and reduction plants on San Francisco Bay this northward expansion was greatly augmented. The fact that this expansion could take place is probably dependent on the wide expanse of shallow water off San Francisco in contrast to a restricted area of shallow water to the south of Monterey. The trend of this expansion has been manifest for more than a decade and the data here presented graphically show the present culmination of this movement.

In southern California, as the industry enlarged, the boats have extended their operations around all the Channel Islands, up the coast as far as Point Conception and southward to Los Coronados Islands just below the international boundary. San Pedro boats occasionally fish as far south as San Diego, but as a rule not much south of Oceanside. The San Diego boats fish from Oceanside southward to Los Coronados Islands. As in central California, figures 85 and 86 indicate the present extension of the southern California fishing grounds. During the past decade no new fishing ports have developed in southern California and as a consequence the location of the fishing grounds has changed but little.

The future of the California sardine fishery remains in doubt. Present indications are that the demand exceeds the supply. To meet this problem in other fisheries, fishing grounds have been extended. For the California sardine, however, the fishing localities appear to be limited to relatively shallow waters most of which are now being exploited from Point Arena south to the Mexican border. In addition all available information indicates that the sardine population moves freely from locality to locality and the development of new grounds would merely draw from the same population as does the present fishery. An increase in the fishery for the California sardine does not, therefore, seem probable.

To avoid confusion the numbers of the blocks are not shown on the maps of figures 85 and 86. For the benefit of those who wish to refer to block numbers, a small key map is inserted on figure 85. This shows the numbers of the blocks and the names of the Channel Islands.

FIG. 87. Map of Lake Arrowhead showing aquatic weed bed areas and location of stations worked.

A BIOLOGICAL SURVEY OF LAKE ARROWHEAD, CALIFORNIA[1]

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U. S. Bureau of Fisheries

INTRODUCTION

In order to obtain the necessary facts upon which to base definite recommendations for the management and stocking of Lake Arrowhead, a biological survey was made of this lake by the writer from November 18 to November 26, 1935, at the request of J. B. Van Nuys, President of the Arrowhead Lake Corporation.[2] This length of time permitted securing adequate samples of the fish population, quantitative and qualitative samples of the available food supply, chemical analyses of the water, and other related information of importance.

Field equipment used consisted of scales for weighing food samples, counting pans, Ekman dredge, field chemical kit, thermometers, Kemmerer water sampler, scale books, gill nets, minnow seines, and other items of lesser importance. Standard lake survey methods were used throughout with one exception, viz.: all bottom food organisms taken in each bottom sample with the Ekman dredge were weighed as well as counted to obtain weight of food per unit area in addition to numbers. By weighing all food organisms taken it has been possible to evaluate the standing crop of available food in pounds per acre of bottom area.

GENERAL FEATURES OF LAKE

Lake Arrowhead lies at an elevation of approximately 5100 feet in the San Bernardino Mountains, less than 100 miles from Los Angeles. It is a typical, cold water, high mountain lake, artificial in point of origin, and was originally intended for irrigation purposes until taken over by the Arrowhead Lake Corporation and devoted entirely to recreational uses. All timber was removed prior to flooding the area and the shoreline therefore lacks drowned timber characteristic of many artificial lakes. Only streams were present originally in the drainage area and as a result several typical lake fish food organisms are lacking that might be expected to be present if the lake were naturally formed and of greater age. The maximum depth is 150 feet, with approximately an average annual drop in level of between three and five feet due to evaporation and domestic use of the

[1] Published by permission of the U. S. Commissioner of Fisheries and the Lake Arrowhead Corporation. Submitted for publication, August, 1937.

[2] Equipment for the survey was loaned by the U. S. Bureau of Fisheries and the field work was carried on by the writer while on annual leave. Mr. Francis Sumner of Santa Barbara assisted in the field work. The Arrowhead Lake Corporation supplied living quarters and meals, boats, outboard motor, and ample field headquarters for the work. My thanks are due Mr. J. B. Van Nuys, President of the Arrowhead Lake Corporation, Mr. Briggs and Mr. Canfield of the administrative staff, Mr. Morris Ellinger, Engineer, and Captain Tuttle and Mr. Probst, boatmen, for much assistance supplied in the course of the field work on the lake.

water. The margin of the lake exposed during periods of low water varies from about 7 to 30 feet depending upon the gradient of the bottom at various points. Unlike most high Sierra lakes, aquatic plants are fairly abundant. The shoreline is fringed by a belt of the reddish-brown water weed, *Ceratophyllum demersum,* except where it has been cleaned away for boating or swimming purposes. Two other aquatic weeds occur in lesser abundance in deeper waters.

Lake Arrowhead, lying as it does close to populous cities in southern California, is fished very intensively. While it is not open to the general public, persons renting boats are permitted to fish. The Lake Arrowhead Corporation owns and manages the lake, and for some years operated a private hatchery in which trout were reared for planting in the lake. State fishing laws relating to seasonal and bag limits are enforced and persons fishing the lake must possess a State angling license.

Over a thousand pleasure boats [3] of all kinds are used on the lake in the summer time, and it is quite remarkable that the fishing has not been completely decimated. Over four hundred summer homes have been built about the lake and the seasonal residents plus transient vacationists in search of sport fishing have put a severe drain on the lake. Such intensity of angling, if any sport fishing whatsoever is to be maintained, calls for a most carefully planned and efficiently executed stocking and management program.

Table 1 shows the points on the lake that were established as stations for obtaining survey data. This was done merely for the purpose of quickly and easily locating points of work on the lake. In addition to the eight stations mentioned in this table, two other areas were worked for analyses of shoal water conditions, viz., the south side of Movie Point and the upper end of Grass Valley Bay. Additional general collections were made both by hand and with the Ekman dredge in all bays at numerous points along the shoreline.

TABLE 1

List of Stations where Survey Data were Obtained in Lake Arrowhead

Station No.	Location	Depth in feet	Type of bottom	Aquatic plants present	Number of bottom samples taken*
1	Center of West Bay	42-45	Silt	None	4
2	Center of lake between Van Nuys and Village points	101-108	Silt	None	4
3	Center of lake southeast of Tract 7	117-125	Silt	None	4
4	Deepest part of lake opposite dam	103-150	Silt	None	4
5	Center of bay northwest of the island	14- 28	Silt and plant remains	*Nitella* in scattered patches	4
6	Center of Grass Valley Bay	20- 40	Plant remains	Algae	4
7	Upper end of North Bay	27- 55	Silt and plant remains	*Nitella* in scattered patches	4
8	Center of North Bay opposite Tract 5	65- 83	Silt	None	2

* In addition to the bottom food samples listed here, six were obtained in water less than ten feet deep on the south side of Movie Pt. and in the upper end of Grass Valley Bay as noted in Table 3.

Temperatures prevailing in Arrowhead Lake the year round are most suited to rainbow trout as shown by the annual records kept by

[3] Information supplied by Captain Tuttle, in charge of boats for the Arrowhead Lake Corporation.

Morris Ellinger, Engineer for Lake Arrowhead Corporation. The following list gives an approximation of the mean monthly temperatures:

APPROXIMATE MEAN MONTHLY TEMPERATURES FOR LAKE ARROWHEAD

January	43° F.	July	68° F.
February	41°	August	70°
March	40°	September	69°
April	48°	October	61°
May	56°	November	49°
June	65°	December	47°

From the above list it is evident that good growing temperatures for trout exist for eight months of the year, from April to November, inclusive. Naturally the mean of any given month will vary from year to year depending upon seasonal conditions, but in so far as the general average temperatures of the lake waters are concerned, rapid growth could be expected over the above named months. At no season do Ellinger's figures show temperatures above the range of tolerance for rainbow trout. Monthly temperatures show the water to be too cold for good development of Loch Leven or brown trout, and too warm for the best results with eastern brook trout. Another strong argument against the planting of these species is that they are fall spawners. At this season the tributary streams are dry or practically so, which would prevent any spawning migrations of these species into the streams. Rainbows are spring spawners, and ample run-off from the tributaries at this season makes it possible to trap breeding fish migrating upstream and to take eggs for rearing in hatcheries. For the above reasons, Loch Leven or brown trout and eastern brook trout should not be planted in Lake Arrowhead.

CHEMICAL ANALYSES OF LAKE WATER

In table 2 is submitted the results of chemical analyses of Lake Arrowhead waters taken at various stations and at various depths. Figure 88 gives the oxygen and temperature curves as taken at station 4 in the deepest part of the lake. Examination of both figure 88 and table 2 indicate that oxygen was deficient for trout below a depth of approximately 100 feet. Trout usually require between four and five parts per million and the amounts shown below the 100-foot level would be insufficient. This by no means is an unusual condition in lakes generally. It merely restricts trout to the upper layers where the oxygen supply is more abundant. Deep water lakes like Lake Arrowhead often show deficient oxygen in their lower waters due to stagnation periods in summer and in winter. Analysis of the oxygen supply of the water at the 80-foot level next to the outlet tower where water supplying the hatchery is taken off, showed 8.32 parts per million, which is ample for hatchery use. Oxygen analyses in Grass Valley Bay and other shallow water areas were shown to be ample in all respects.

Slightly alkaline conditions existed in the upper layers of the lake surface waters showing a pH of 7.7, and at the 50-foot level a pH of 7.5. Deficiency in oxygen with proportional high increase in

CO_2 reduced the pH to an acid condition below the 100-foot level where the pH was found to be 6.8.

Methyl orange alkalinity, i.e., the determination of alkalinity in terms of calcium carbonate, were made because of the importance of this factor in the production of aquatic fish foods. Waters relatively rich in calcium carbonate are known to produce more fish food than

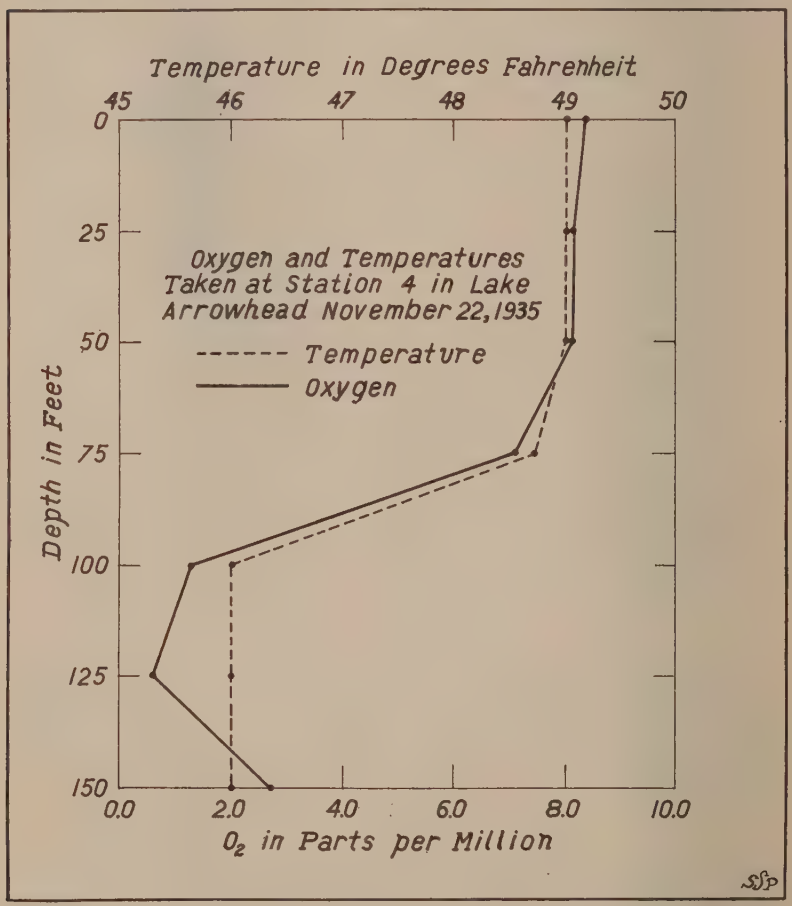

FIG. 88. Oxygen and temperature chart for Lake Arrowhead.

waters deficient in this salt. Two such determinations made of the surface and bottom waters at station 4 showed 23 and 24 parts per million, respectively, of calcium carbonate. These amounts are more than is usually found in high Sierra lakes and is reflected in existing food conditions.

FOOD SUPPLY OF LAKE ARROWHEAD

There are four types of food available to trout in Lake Arrowhead: bottom foods, plankton, drift food, and the young of all fishes present

in the lake. Bottom dwelling forms consist largely of midge larvae and pupae, *Corethra* (*Chaoboris*) larvae, with a scattering of damsel fly nymphs occurring in shoal areas. Plankton consists of minute plants and animals that are free-swimming, short-lived forms, and includes a great variety of crustaceans, protozoans, algae and rotifers. The crustaceans are the most important group of plankton in so far as the food of trout in the lake is concerned. Large numbers of water fleas, *Daphnia,* belonging to this group were taken from the stomachs of trout caught in gill nets. Copepods and ostracods are likewise important as food and also belong to the Crustacea. Drift food consists largely of terrestrial insects that are blown into the water from the land during the warmer months of the year. This type of food furnishes a very considerable portion of the food of trout in mountain lakes in the summer time, as shown by stomach examinations.

TABLE 2

Chemical Data Taken in Lake Arrowhead, November 22, 1935

Station No. or location	Depth in feet	Temp. ° F.	0_2 ppm.	pH	M.O. Alk. in ppm. Ca CO_3
4	Surface	49.0	8.32	7.7	23
	25	49.0	8.08		
	50	49.0	8.15	7.5	
	75	48.7	7.06		
	100	46.0	1.26	6.8	
	125	46.0	0.63		
	150-B*	46.0	2.66	6.8	24
1	Surface	49.0	8.64		
	56-B*	49.0	7.38		
2	107-B*	53.0	0.54		
Outlet tower	80	48.5	8.32		
Grass Valley Bay	Surface	48.5	7.06		
Grass Valley Bay	10-B*	50.0	8.08		

* Indicates the bottom at this depth.

It is possible to measure accurately the amounts of bottom foods present in lakes and this was done in the survey of Lake Arrowhead. It is not possible, however, to measure accurately the amounts of food supplied by the plankton, drift, or young of fishes. Only rough estimates of the amounts of these foods were made and applied in the formulation of the stocking policy in relation to the food supply.

Bottom Foods

Thirty-six quantitative bottom food samples were taken in the lake with the Ekman dredge. This apparatus secures samples covering 36 square inches of bottom or one-quarter of a square foot. Both numbers and weight of food per square foot, per acre, or by depth zones have been determined by calculations from the original data determined from each sample or averages of same.

TABLE 3

Tabulation of Bottom Foods. Samples Taken With Ekman Dredge in Lake Arrowhead Survey

Station no.	Date	Sample No.	Depth in feet	Wet wt. of food in grams	Number of organisms		
					Midge larvae	*Corethra* larvae	Damsel fly nymphs
1	11/20/35	1	45	.065	12	5	0
		2	45	.04	7	10	0
		3	45	.05	9	17	0
		4	42	.05	9	12	0
2	11/20/35	1	101	+	0	2	0
		2	101	+	0	2	0
		3	102	+	0	1	0
		4	108	+	*0	*0	*0
3	11/20/35	1	117	+	0	0	0
		2	117	+	0	0	0
		3	125	+	0	0	0
		4	120	+	0	0	0
4	11/20/35	1	125	+	0	0	0
		2	103	+	0	0	0
		3	141	+	0	0	0
		4	150	+	0	0	0
5	11/21/35	1	14	.125	19	8	0
		2	15	.015	2	2	0
		3	22	.01	3	2	0
		4	28	.06	3	29	0
6	11/21/35	1	20	.005	6	0	0
		2	20	.013	5	5	0
		3	32	.025	12	1	0
		4	40	.13	50	44	0
7	11/24/35	1	27	.055	23	2	0
		2	37	.02	7	0	0
		3	43	.065	21	1	0
		4	55	.005	2	0	0
8	11/24/35	1	65	.01	1	0	0
		2	83	.01	1	0	0
Shoal samples** where taken							
South side Movie Pt.		1	4	.05	20	0	17
Near shore		2	4	.03	53	0	5
Middle of weed bed		3	5	.042	20	0	4
Submerged weed zone		4	10	.015	16	0	6
Grass Valley Bay, in weed zone		5	10	.010	10	2	0
Grass Valley Bay		6	2	.025	12	0	16

* Only bristle worms (oligochaetes) that are not eaten by trout were taken in most of the deep water bottom samples, and a "plus" (+) has been used to indicate their presence where other true food organisms were lacking

** Taken November 25, 1935.

TABLE 4

Weight of Bottom Foods Present in Lake Arrowhead by Depth Zones

Depth zone	Number of samples	Wet weight of food*		
		In grams per Ekman sample	In grams per sq. ft.	In pounds of food per acre
0– 10 ft.	6	.0286	.1144	11
11– 20 ft.	4	.0395	.1580	15
21– 50 ft.	11	.0518	.2072	20
51–100 ft.	3	.0083	.0332	3
100 ft. up	12	+	+	+

*Wet weight of food was found by sorting organisms out of each sample, drying them for a standard time of one minute on blotting paper, and weighing on a sensitive scale.

TABLE 5

Numbers of Fish Food Organisms Taken in Bottom Samples by Depth Zones

Depth zone	Number samples	Food organisms			
		Average number per sq. ft.	Number per sq. acre	Dominant forms	Miscellaneous
0– 10 ft.	6	120.64	5,255,078	Midge larvae	Damsel fly nymphs
11– 20 ft.	4	47.0	2,047,320	Midge larvae	None
21– 50 ft.	11	101.44	4,418,726	Midge larvae	None
51–100 ft.	3	5.33	232,174	Midge larvae	None
101 ft. up	12	+	+	Bristle worms	None

TABLE 6

Total Standing Crop of Available Bottom Foods in Pounds per Acre by Depth Zones, Lake Arrowhead, November, 1935

Depth zone	Acres*	Lbs. per acre	Total pounds of bottom foods
0– 10 ft.	70	11	770
11– 20 ft.	70	15	1,050
21– 50 ft.	210	20	4,200
50–100 ft.	280	3	840
100 ft. up	120	+	+
Totals	750		6,860
Average			9.14 lbs. per acre

* Based on level of lake, 5,102 ft., January 30, 1936.

Weight of Bottom Foods

In table 3, will be found the complete data on each sample taken. In table 4, the weights have been averaged and calculated to show wet weight of food by depth zones. Here it is shown that the most food by weight was available in the 21-foot to 50-foot zone which averaged 20 pounds per acre. The 11-foot to 20-foot zone showed 15 pounds per acre, the second highest weight, while the 0-foot to 10-foot and 51-foot to 100-foot zones averaged 11 pounds and 3 pounds per acre, respectively. Bottom samples taken in water over 100 feet deep were entirely lacking in trout foods. Lack of oxygen in the deeper layers,

as shown in table 2, is undoubtedly a major cause of the paucity of food organisms in this zone. Bristle worms (oligochaetes) were abundant in all samples taken in water over 100 feet deep. These organisms, while forming an important link in the ecology of lake waters, nevertheless are never eaten by trout, and no counts or weights of these animals were made from the bottom samples.

Numbers of Bottom Foods

In table 5 is shown the numbers of organisms calculated for each depth zone to numbers per square foot and numbers per square acre. Here it is evident that, by numbers at least, the shallow water 0-foot to 10-foot zone was richest, averaging over 120 organisms per square foot. The 21-foot to 50-foot zone was next, showing over 100 per square foot. The 11-foot to 20-foot zone was third, averaging 47 per square foot, while the 51-foot to 100-foot zone gave a figure only slightly over 5 organisms per square foot.

As noted previously the dominant bottom foods occurring in the samples were midge larvae and pupae (Chironomidae), phantom midge larvae (*Corethra*), and damsel fly nymphs (Odonata). No scuds, shrimp, beetles, water boatmen or other aquatic Hemiptera, caddice fly larvae or pupae, mayfly nymphs, or other forms, that are often found in lakes, were taken in the quantitative samples or in general hand collecting. Empty larval caddice fly cases were found in the trash from bottom samples, a fact that indicates that the members of this group are present, but scarce, in the lake.

By numbers, midge larvae and pupae formed 57 per cent and phantom midge larvae 43 per cent of total bottom organisms in water over 10 feet deep. Both the members of these groups (families Chironomidae and Culicidae) belong to the order Diptera or true flies and hence it may be said that the bulk of the food in the lake consists of "fly" food. In shallow water less than 10 feet deep, midge larvae and pupae formed 72.4 per cent of the total numbers and phantom midge larvae and damsel fly nymphs formed 1.1 per cent and 25.6 per cent, respectively, of total numbers of potential available foods.

Weight Compared to Number of Food Organisms Present

It is evident in table 5, that in so far as numbers are concerned the 0-foot to 10-foot zone was richest in food. On the other hand, in table 4, it has been shown that by weight the 21-foot to 50-foot zone was richest, our measure showing a standing crop of 20 pounds per acre available. It is a well known fact that the shoal areas of lakes produce the largest amounts of food for fish. This is generally true in most lakes and from the standpoint of numbers, holds true for Lake Arrowhead as well. However, total weight or bulk of food is far more important than numbers of food organisms from a fishcultural standpoint. Using this criterion then, we would say, on a basis of pounds of food per acre, the 21-foot to 50-foot zone offered the largest amount of potential food even though the 0-foot to 10-foot zone offered greater numbers of food organisms. The discrepancy between weights and numbers is more apparent than real and the reason obviously lies in the bulk or weight of the individual organisms taken in each zone. The 0-foot to 10-foot zone averaged 120 per square foot (table 5) but

these were mostly small in size, giving a weight of food of only 11 pounds per acre. The 21-foot to 50-foot zone, on the other hand, averaged only 101 per square foot in numbers but gave a total weight of 20 pounds of food per acre due to the presence of many larger and heavier organisms.

Total Standing Crop of Bottom Foods

In order to arrive at a measure of the total standing crop of available bottom foods, it was necessary to determine the approximate acreage in each depth zone. Ellinger very kindly supplied the writer with a curve giving area in acres plotted against elevations of the lake basin, from which these were secured.

In table 6, these data are shown along with the total amounts of food present in each zone. This table represents the end point of the aims in sampling bottom fauna of Lake Arrowhead. Here it is shown that a total of 6,860 pounds of food were available in the lake as a whole at the time the survey was made, or an average of 9.14 pounds per acre. This average per acre compared to other high mountain lakes in California is only *fair*. Food conditions as a whole in the lake, covering all aspects, may also only be said to be fair. As noted below, it may be possible to greatly improve the food supply by the introduction of food organisms not now present in the lake.

It should be stated that the above total weight of food is a measure of the standing crops only as found at the season of the year the survey was made. Had the survey been made in July or August undoubtedly more seasonal land and aquatic foods such as beetles, bugs, and other organisms would have been found that would have shown somewhat more abundant food supplies available in pounds per acre. Further, the above figures give no indication of the rate of replacement or "turn-over" of bottom foods. It is well known that organisms such as midges produce several generations in a single growing season and this fact too must be kept in mind in calculating total foods against productivity in trout.

Plankton

Free-swimming plankton organisms were collected by means of a fine-meshed net drawn behind a boat. These plants and animals are to lakes what green vegetation is to the land—the basic source of all food.

The dominant form collected was *Mougeotia,* a filamentous green alga. So abundant was this in the lake at the time the survey was made, the water was tinged a definite green. The transparency of the water was likewise materially reduced. In addition to *Mougeotia,* the desmid, *Staurastrum,* was fairly common as well as the water fleas *Bosmina* and *Daphnia.* The three flagellates, *Volvox, Ceratium,* and *Eudorina* occurred occasionally as did a few rotifers and protozoans. The plankton found may be said to be typical of lakes in general, and furnishes considerable amounts of food annually to trout. While the organisms contained in the plankton are small, they make up in numbers what they lack in size. Hundreds of the water fleas, *Daphnia,* were taken from the stomachs of trout caught in a gill net set made in Emerald Bay, as noted below.

AQUATIC PLANT BEDS

As noted in the introduction, three types of aquatic plants are fairly abundant in Lake Arrowhead. *Ceratophyllum demersum* is dominant. It forms extensive beds in the shallow, upper portions of most of the bays and is particularly abundant in Grass Valley, Ice Rink, Burnt Mill, and Flemming bays. It also forms a marginal fringe along most of the shore line in water from two to eight feet deep.

The other two plants that occur in lesser abundance in deeper water are the pond weed, *Potamogeton crispus,* and the bottom dwelling alga, *Nitella.* The former is commonly found in water between ten and fifteen feet deep, and the latter prefers deeper water from fifteen to thirty feet in depth. *Nitella* was particularly abundant off Van Nuys Point and in Burnt Mill Creek Bay.

All the above plants are of the greatest value in assisting trout production in Lake Arrowhead. The *Ceratophyllum* particularly furnishes much food for the aquatic invertebrate fauna that serve as direct food for small trout, and the shelter afforded young, newly planted fry or fingerlings in the interlacing stems and leaves must prevent a considerable amount of cannibalism by the larger fish in search of food. Some shelter and food are supplied likewise by the *Potamogeton* and *Nitella,* but in considerably smaller amounts due to their lesser abundance in the lake.

FISHES PRESENT

The following species of fish were taken by means of gill nets in the course of the survey: rainbow trout, *Salmo gairdnerii;* squaretail catfish, *Ameiurus nebulosus;* and the green sunfish, *Apomotis cyanellus.* No Loch Leven trout or goldfish were taken though both are said to be present. A Loch Leven trout, weighing 16 pounds 9 ounces, was caught in the lake one summer a few years ago.

All three species taken in the gill net sets may be considered as game fishes. Catfish and sunfish readily take baits offered by "still" fishermen, as do the smaller rainbow trout. Most of the larger trout are taken on trolling rigs. The green sunfish is the only spiny-rayed fish present in the lake and is normally an inhabitant of warm waters, being commonly found associated with bass, perch, bluegill sunfish, and other species. It is the opinion of the writer that green sunfish are not at present harmful to the balance of fishes in Lake Arrowhead, but it is important that no other spiny-rayed fishes, such as bass or perch, should under any conditions be planted in the lake. Very definite harm would result to the trout fishing. Doubtless sunfish offer young trout considerable competition for food though it is also probably true that young sunfish are eaten in considerable numbers by adult trout, though none were found in the stomachs of the twenty-eight trout examined.

In eastern waters catfish are found commonly associated with eastern brook trout under natural conditions. Since catfish eat different foods than trout, in Lake Arrowhead these fish should not seriously hamper the development of good trout fishing.

Abundance of Fish

In table 7 are shown the catches taken in three gill net sets fished a total of 45 hours. A total of 28 rainbow trout, 16 sunfish, and 7 catfish were caught. It may be said from these figures that the trout population of the lake is low, as this amount of gill net fishing in lakes having abundant fish population will catch much greater numbers of fish in considerably less time. The total catch of all species was 0.5 fish per hour in set No. 1, 0.75 fish per hour in set No. 2, and 1.3 fish per hour in set No. 3 (table 7). The average over the three sets and points fished was 0.86 fish per hour without adjusting for either variations in type of nets used or localities fished.

TABLE 7

Fish Taken in Gill Net Sets in Lake Arrowhead

Location of set	Number, mesh and size of net	Number fish caught			Total hours fished	Set No.	Date
		Rainbow	Catfish	Sunfish			
Ice Rink Bay opposite lots 5, 6 and 7, Tract 50.	1-net, 100 ft. long, 5 ft. deep, 5 sizes of mesh.	2	0	5	14	1	Nov. 20-21, 1935
Off point, between Grass Valley and West bays	2-nets totalling 220 ft. in length by 5 ft. deep each, of five sizes of mesh.	9	1	11	28 (both nets)	2	Nov. 21-22, 1935
Off east shore of Emerald Bay	1-net, 125 ft. long by 6 ft. deep; 1" sq. mesh only.	17	6	0	17	3	Nov. 25-26, 1935
Totals		28	7	16	59		

If the relative proportion of each species as taken in the gill nets is used as an index of the relative abundance of each in the lake itself, rainbow trout form 55 per cent of the population, catfish 7 per cent, and green sunfish 31 per cent, respectively. Since the gill nets were set at depths up to only about 60 feet, these proportions could only be said therefore to apply to the shallow water portions of the lake. However, since low oxygen was found below the 100-foot depth, which would tend to drive the fish into the upper layers, the chances are that the net catches represent a fair index of the relative abundance of each species.

Size of Fish

The 28 rainbow trout taken (table 8) averaged 9.8 inches in length. The largest taken was a female 20.25 inches long, weighing 3.92 pounds. The smallest taken was a male 7 inches in length. The data were statistically treated and the probable error of the average length was found to be $\pm$ 0.31 inch indicating that a like sample taken under the same conditions would not vary in the average length more than 0.31 inch above or below the average of the 28 trout taken.

The average length of the catfish and sunfish taken was 7.4 inches and 4.3 inches, respectively.

The average weight of the rainbow trout was approximately half a pound (0.48 pound, table 8). Fish of this size offer good sport

fishing with flies and are the proper pan size. A large population of medium sized trout for a large number of anglers is far preferable to a light population of large sized trout that would offer sport to only a few anglers. It should be the aim of the stocking policy to supply large numbers of trout running between one-quarter and half a pound.

TABLE 8

Data on Rainbow Trout Taken in Gill Net Catches

Gill net set no.	Total length in inches	Weight in lbs.	Sex	Condition factor
1	20.25	3.9200	Female	47.20
2	14.0	.9531	Female	34.73
1	13.5	.8281	Male	33.65
2	10.5	.4843	Male	41.83
3	10.5	.3750	Female	32.39
3	10.12	.4453	Female	42.90
3	10.0	.3828	Female	38.28
3	9.87	.3828	Female	39.75
3	9.75	.3906	Female	42.14
3	9.75	.4062	Female	43.82
2	9.62	.2968	Female	33.28
3	9.37	.3203	Female	38.87
3	9.37	.3437	Female	41.66
3	9.25	.3281	Female	41.45
3	9.12	.2968	Female	39.06
3	9.0	.2812	Male	38.57
3	9.0	.3671	Male	50.35
3	8.87	.2734	Female	39.11
3	8.87	.2656	Female	38.00
2	8.75	.2656	Female	39.64
3	8.75	.2578	Female	38.48
2	8.75	.2812	Female	41.97
2	8.75	.2656	Male	39.64
3	8.62	.2421	Female	37.73
2	8.62	.2656	Female	41.40
2	8.12	.2187	Female	40.77
3	8.0	.2343	Male	45.76
2	7.0	.1562	Male	45.53
Averages	9.8	0.48		40.28

Condition of Trout

The "condition factor" is commonly used by fish culturists as a measure of plumpness in relation to length. Many lakes overstocked and underfished in relation to the available food supply will often produce long, big headed emaciated trout having very low condition factors around 25. Such fish are of little sport or food value. The condition factors of fish in excellent condition will run between 39 and 45. A factor of 42 is considered average. Condition factors are determined by the following formula:

$$\frac{\text{Weight in pounds}}{(\text{length in inches})^3} \times 100{,}000$$

In table 8 it is shown that the average condition factor for the 28 rainbows was 40.28. The lowest obtained on any single fish was 33.28 and the highest was 50.35. The largest fish taken was a female weighing 3.92 lbs. Her condition factor was 47.20 and undoubtedly, since she contained many developing eggs, the additional weight of same contributed materially to produce a high factor. In brief, the present trout population of Lake Arrowhead is in excellent condition. Internal

examination showed much fat in the body cavity. The fish are small headed, deep bodied and in all respects in first class condition. It is quite evident that the lake at present is not overstocked in relation to the food supply.

Age of Trout as Determined from Scale Readings

Scales were taken from all trout caught in gill nets, mounted on slides, and examined microscopically. The bulk of the fish taken were found to be in their second and third years. Only a single fish had spawned once as shown by a spawning "check" on its scales. This was the largest fish taken, a 3.92 pound female apparently four years old, and it was evident from the eggs she contained that she would have spawned again in the spring of 1936 had she not been caught. A few males and females of those taken would have spawned in the spring of 1936 as shown by the condition of the gonads. However, it was evident with the fish examined, that the bulk of them would spawn for the first time at the end of their third year. Other work on rainbow trout in high mountain lakes in California has shown that a few of the larger rainbows will spawn in their third year, though it is generally believed that the greater proportion of them perform this function for the first time in their fourth year. This fact should be kept in mind when protective measures are adopted for the lake, so that a sufficient escapement from anglers may be assured that will reach breeding age to provide the necessary egg supplies for restocking the lake.

Scales of roughly half of the fish showed first year growth typical of hatchery fish and were evidently the result of plants made from hatcheries in previous years. Several scales were doubtful reading in this respect and it could not be determined for certain whether they were the result of hatchery or natural propagation. Many showed definite stream growth on their scales. Evidently some spawning fish escaped the traps to spawn naturally in the tributary streams, the resultant young surviving to reach the lake to continue their growth. Last August numerous naturally spawned young rainbows were seen in the deeper pools of Grass Valley and Little Bear creeks. Since all the tributary streams of Lake Arrowhead dry up or become very low in late summer and fall, it is far better to take the eggs artificially than to permit natural spawning where the chances of survival of the resulting young are low.

Trout Stomach Examinations

The stomachs of all trout taken in gill nets were examined and the food content recorded.

Fish taken in gill net set No. 3 had consumed more water fleas, *Daphnia,* than any other food. These free-swimming crustaceans were absent from the stomachs of the nine rainbows taken in set No. 2. The latter fish contained midge larvae and pupae as the dominant food. In contrast, the seventeen rainbows taken in set No. 3 contained but few midge larvae and pupae, over 98 per cent being water fleas as noted above. A few phantom midge larvae, *Corethra,* were found in a few stomachs though the total number eaten was low. Young fishes were

absent from all stomachs. Damsel fly nymphs were likewise lacking in the stomachs.

A few terrestrial ants and beetles were found in a number of stomachs; organisms that had fallen into the water accidentally. Land foods blown or falling into lake waters in the warmer months of the year contribute very considerable amounts of food to trout and other fishes. During June, July, and August as high as 50 per cent of the diet may be supplied from this source. Small bits of the aquatic pond weeds, *Potamogeton crispus* and *Ceratophyllum demersum,* occurred in a few of the stomachs.

In summary, the chief foods eaten by the trout examined were water fleas and midge larvae and pupae. Phantom midge larvae, terrestrial insects and parts of aquatic plants occurred in lesser abundance.

ESTIMATED ANNUAL PRODUCTION OF TROUT

As noted above, the total standing crop of available bottom foods was shown to be 6,860 pounds. In addition, plankton and drift foods will also furnish a considerable amount of food but it is not possible to arrive at a definite weight of food supplied by these two sources. Further, since considerable replacement or "turn-over" of bottom foods takes place annually, we are justified, I believe, in taking two times 6,860 pounds or 13,720 pounds as the total estimated weight of all foods available to trout in Lake Arrowhead annually. It should be made clear that such fishcultural facts relating to the total weight of plankton and drift foods or rates of replacement of all foods and their actual availability to trout as compared to their "potential" availability, have not been worked out on a scientific basis as yet and the facts will carry us only part of the distance in developing really scientific stocking policies today. Accumulated fishcultural experience and detailed studies of the type made here offer a far firmer starting basis, however, than the guesses of individuals unacquainted with the biological problems involved.

To continue, if an estimated total of 13,720 pounds of food is available to trout annually in Lake Arrowhead and if it requires approximately eight pounds of natural food to produce one pound of trout, then an estimated total of 1,715 pounds of trout should be produced annually. If the trout run about the same average weight and length as those taken in the gill net catches (approximately half a pound apiece or eight to ten inches in length), they will run from two to three to the pound. Using the figure of 2.5 fish to the pound, this would give an annual production of approximately 4,300 trout or 5.7 fish per acre. Since the catfish, sunfish and goldfish present will consume a portion of the food, these figures would have to be reduced somewhat. It is the writer's opinion after figuring production from all aspects, that the lake should produce between 3,000 and 5,000 trout annually as a rough estimate of the lower and upper limits.

STOCKING POLICY

Submitted below in Table 9, are two alternate stocking policies for Lake Arrowhead. The numbers and sizes recommended in each are based upon the estimated "biological capacity" of the lake from studies made of the food supply given above.

If only small fish around one inch in length are to be available for planting purposes, 300,000 (policy 1) of this size planted annually should give a return of from 3,000 to 6,000 fish annually to fishermen. It seems evident from examination of the egg "take" records of previous years at Arrowhead that ample eggs could be secured to eye, to hatch and to plant this number of fish annually, provided, of course, that the adult breeding population is not removed by over-fishing. Planting of small fish would be the cheapest method, but probably also, the least satisfactory for reasons noted below. Trout planted when an inch in length would be taken by anglers in their second summer, but by far the greatest number would be taken in their third summer, and the survivors in their fourth and later years.

TABLE 9

Two Stocking Policies Recommended for Lake Arrowhead

Policy no.	Species	Size in inches	No. per acre*	Total	Frequency	Expected mortality, percentage
1	Rainbow	1	400	300,000	annually	98-99
2	Rainbow	3-4	26.6-40	20,000-30,000	annually	40-60

* Based on surface area of 750 acres when the elevation of the lake is 5,102 feet.

Policy 2, which recommends from 20,000 to 30,000 rainbow trout from three to four inches in length, would give more immediate and better results though the cost of raising same would be considerably higher than for the smaller fish. These fish, if reared in Lake Arrowhead Hatchery from eggs taken in the lake, would have to be held and fed in the rearing ponds until September or October when they should average between three and four inches in length. It would be best to plant them with the advent of low water temperatures in the fall, as the cost of labor and food would overbalance the very poor growth obtainable over the winter months. In addition, by planting them after the fishing season had closed, greater protection would be afforded and many would have achieved good pan size by the opening of the fishing season the following spring.

In intensively fished waters such as Lake Arrowhead, far better results will be had by planting large fish. This has been proved time and again by past fishcultural experience.

The carrying capacity of a body of water is far greater than its biological capacity. For instance, it would be possible to plant say 25,000 large fish over six inches long annually in the lake and food capacity might be sufficient to maintain or "to carry" them but it would be insufficient to permit proper growth. Further, trout of this size are usually planted with the expectation that over 95 per cent of them will be removed in the same fishing season in which they are planted. This system could be followed in Arrowhead if the funds to rear or to buy trout over six inches long were available, but it seems to the writer that utilization of the normal productivity of the lake by means of carefully balanced management and stocking procedures would give more satisfactory results in the long run. The lake will never, biologically, be able to produce all the pounds of fish that the hundreds of anglers who fish it would like to catch. The two alternatives are to plant large numbers of fish six inches or larger in size

regardless of the available food supply, or to plant smaller numbers consistent with the biological capacity of the lake and then restrict the "take" in proper relation to the supply.

While the writer recommends stocking policy 2 (table 9), the numbers suggested may be somewhat high in relation to actual food conditions. However, it is anticipated that if three- to four-inch fish are planted in the fall, by the following summer many will be of catchable size and will be removed at this time, which in turn reduces the demand for food by the total remaining population. Further, to plant three- to four-inch fish is to produce a considerable "poundage" of the fish on artificial food in the rearing operations, the fish are protected over the period of greatest mortality when young, and the drain on the food supply is limited to the amounts necessary to grow them to say six inches or a catchable size when many will promptly be caught by anglers. In other words, using policy 2 is "stepping up" potential production by the lake without menacing the amount of food available to permit good growth of the survivors of each fishing season to sexual maturity.

A real danger exists in over-stocking in relation to the food supply. If this is done, big headed fish of poor condition will result, and in a case of this kind it is far better to plant too few rather than too many. It is believed that neither of the policies submitted is out of line with the basic food conditons in the lake.

The policies submitted are in no sense final. They should be carefully balanced against actual catch records annually and modified as appears necessary. Further, in case new food organisms and plants are introduced and become established to improve the food supply, it may be possible to greatly increase the numbers planted and consequently fish production of the lake. The number of trout trapped annually for egg collections and their size, growth and condition will give further evidence of necessary modifications both as to planning and restrictive measures.

CATCH RECORDS

It is suggested that a record be obtained of all fish caught by fishermen on the lake. From a record of this kind the catch per unit of effort could be determined as well as a fair estimate of the total annual catch. This would give direct means of measuring the trend of fishing from year to year following upon any stocking policy or management plan put into effect. Report blanks for recording catches made by anglers could be printed and supplied in book or pad form. Two types of blanks would be desirable; one for recording reports of boat fishermen and one for anglers who fish from the shore.

Since voluntary returns obtained from anglers have been proved quite incomplete and inaccurate as shown by past catch record work, special persons such as wardens, hatcherymen, boatmen or others would have to be assigned to take down the records by contacting anglers. It is most difficult to get anglers to record their catches. They are usually in too much of a hurry or they find it too much trouble to study the blanks provided to learn how to fill them out properly, and it appears now that if adequate voluntary catch records are to be obtained they must be taken under the very close supervision of trained workers or by other special means.

One most important aspect is that the record be filled out immediately upon conclusion of any given fishing period for any one day before remembrance of catch and hours fished had faded. To determine catch per unit of effort, it is highly important that the *hours fished* be recorded. Blanks should be filled out for all fishermen regardless of *whether or not* fish are actually caught.

If the above suggestion for obtaining catch records on Lake Arrowhead is placed in operation, the facts determined should form a sound basis upon which to erect future management and stocking policies. Such records would also assist in the development of better methods of management with regard to similar bodies of water.

GENERAL RECOMMENDATIONS

A. As to Protective Measures

1. Open fishing season of four months, from June 1st to September 30th, or possibly May 15th to September 15th.
2. Daily bag limit of ten trout or five pounds and one trout.
3. Daily bag limits of twelve catfish and twenty sunfish.
4. Minimum size limit of six inches on trout; no size limit on catfish or sunfish.
5. Rigid protection of large trout from poachers when on their spawning migrations into the small tributary streams in the spring.

An open season of six months and a bag limit of twenty-five trout regardless of size as now in effect, are entirely out of proportion to the supply of available fish in a lake as accessible and as intensively fished as Lake Arrowhead. A size limit prevents wholesale slaughter of immature trout and makes for greater poundage rather than numbers in the catches. If no size limit is put into effect in the lake, then stocking policy No. 1 (table 9) is recommended because the larger fish suggested under policy No. 2 should be given a chance to reach good pan size before they are caught.

A reduction of bag limit lowers the limit catches of expert fishermen and gives greater spread of the fish supply among a greater number of anglers.

B. As to Hatchery and Planting Operations

1. Take surface water supply from lake for hatchery and rearing ponds and use by mixing with present supply from the 80-foot level.
2. Redesign and rebuild present hatchery ponds into raceways for more efficient operation.
3. Take eggs by trapping spawners annually.
4. Plant only rainbow trout.
5. Secure catch records annually.
6. Plant all trout in dense weed bed areas in shallow bays and along shores where good protection will be had. Distribute only a few at any one place; distribute as widely as possible.

The present trough capacity of the hatchery is adequate to hatch all eggs needed for stocking Lake Arrowhead. The present pond

system at the hatchery could be improved for more efficient operation. Shallow concrete raceways, 20 feet long by 3 or 4 feet wide, with concrete bottoms having adjustable depths from 6 to 18 inches, would be more efficient both from feeding and disease control standpoints.

Water supplied from the surface of the lake will permit mixing the present cold water taken from the 80-foot level with warmer surface water to obtain any temperature between the minimum and maximum of either source of supply and will give far better growing temperatures, at least in the warmer months, for hatchery and rearing pond operations. Unless better growing temperatures than from 42° F. to 46° F. are obtained, operation of the hatchery is not recommended.

The ultimate degree of success attained in egg collecting, hatching and rearing operations will depend entirely upon the training and ability of the man in charge of the work. Accurate cost records of all operations should be kept. Mortality records, food fed, water temperatures, growth rates and similar data will give an index of the costs involved that can be used as a check on the results obtained. Modern trout diets should be used as well as modern methods of disease control.

C. As to Improvement of the Natural Food Supply in Lake Arrowhead

1. The introduction of two kinds of snails, *Lymnaea* and *Physa*, both of which normally occur in similar lakes.
2. Introduce the small scud, *Hyalella azteca*, and the large scud, *Gammarus limnaeus*.
3. Introduction of the aquatic plant, *Elodea*.

The introduction of the above organisms, if successful, would do much to improve the food supply of Lake Arrowhead. Conditions seem best suited to the snails and the small scud (*Hyalella*), though an attempt should be made with the large scud (*Gammarus*) as well. It is impossible to predict success or failure from such attempts in the present state of our knowledge. All the above forms can be found growing naturally in lakes or streams of the middle Sierras.

One point that should be mentioned in connection with natural food supply is the danger to same of oil pollution from motor boats operated on the lake. Oil on water is very harmful to aquatic insects, often preventing their normal emergence from the water and later reproduction. There is a very real danger in this respect at Lake Arrowhead due to large numbers of boats concentrated in a comparatively small area. No evidence of oil pollution was seen at the time the survey work reported on here was conducted.

In conclusion, if Lake Arrowhead is to be brought to its maximum productivity, carefully planned stocking and management policies must be placed in effect. If these are modified from year to year in light of additional facts, produced both by catch records showing the annual range and size of the fish crops, and by later biological re-surveys to determine changes in the food supply, fishing in the lake should be steadily improved from season to season.

A METAL PLANKTON NET [1]

By Donald H. Fry, Jr.
California State Fisheries Laboratory
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The California sardine and the Pacific mackerel both spawn in the open ocean. The eggs float freely in the water and hatch in less than a week (the exact time depends on temperature and may be as short as two days). The California Division of Fish and Game is engaged in mapping the areas in which the spawning is done, and in noting changes from year to year. This work is done by towing cone-shaped nets behind the research boat. If no eggs are taken we know that there has been no spawning of any importance in that spot during the previous week, conversely if we do find eggs we know that there has been some spawning. As a general rule there is no need to take ocean currents into account in studying eggs which hatch as quickly as do those of the sardine and mackerel.

Part of the egg collecting work is done with a special metal net, designed at the California State Fisheries Laboratory. There would have been no need for this piece of equipment if sardine and mackerel eggs were always uniformly distributed throughout large areas of water. It was the discovery that their distribution is often very patchy that led to the building of a metal net which could be towed continually at the ten-knot cruising speed of our research boat. With this device we are able to pass through waters where we do not expect to find anything and be absolutely sure that we have not missed any patches of eggs. To do this with the usual type of silk net would require a haul every 10 or 15 miles and a loss of 15 or 20 minutes for each haul, i.e., a loss of four to eight hours per day.

Though not intended for fish larvae, this net takes a surprising number of them in spite of its small opening. Apparently its high speed simply does not give the larvae time to get out of the way.

When towed at 10 knots, the metal net is never more than a few feet under the surface. This makes it useless for even roughly estimating the quantities of eggs in a given area, and for some species of fish would make it entirely useless. Fortunately for us, sardine and mackerel eggs float in the upper layers of water, so we can always be sure of picking up some if they are present in large enough numbers to be worth considering. Fish eggs are often very much more abundant at one depth than at another, hence to arrive at any sort of an estimate of the numbers in an area, it is necessary to sink a tow net below the deepest depth at which the eggs are found and drag it to the surface either vertically, diagonally, or in a series of horizontal drags at different depths. About 150 feet appears to be deep enough when collecting sardine or mackerel eggs.

[1] Submitted for publication, August, 1937.

The metal net is constructed of stainless steel throughout. It is five feet long and has a four-inch opening (Fig. 89). Back of the opening there is a collar which widens to 10 inches, and then comes a cone of screen, 40 meshes to the inch. This screen is guarded by a frame of stainless steel. The small opening and large area of screen combine to give plenty of filtering surface and so reduce back pressure inside the net. The large screen area also takes much longer to clog than would a smaller screen with the same sized opening. At the lower end is a cup which screws in place. A small screen-covered opening in the side of this container lets some water flow through and makes sure that everything that gets into the net washes well down into the cup.

The net is towed on the end of a $\frac{3}{8}$-inch steel cable; not because anything that strong is needed but because the weight of the cable helps sink it under water. Two hundred and fifty to 300 feet of cable will sink the net far enough so that it will not break the surface. When given less than 200 feet of cable, it will pop through a wave every now and then, and when really close to the boat it skitters and bounces along the surface.

FIG. 89. The high speed metal plankton net developed by the author. The measuring stick is one meter (39$\frac{3}{8}$ inches) long.

Material caught in the metal net is shaken up pretty badly. All the fish larvae and a majority of the small crustaceans are killed, but fish eggs are usually still living and uninjured.

The net is usually hauled in every two, three or four hours. The time depends on the rapidity with which water conditions are changing. Once one of our research men, while holding onto the widely cavorting boat with both hands, shouted, "As far as I am concerned that net can stay out till it calms down a little. I don't want to get washed overboard." That haul lasted eight hours.

When the net is brought aboard it is reeled in rapidly until within a few feet of the boat, then the winch is stopped and started again as slowly as it will go. This precaution is necessary to keep the net from jumping out of the water and slamming into the rail. When it is pulled in slowly a man can catch it and fend it off until it has been reeled right up to the block (this block is hung over the stern and about ten feet above deck level). Then the cup is unscrewed and emptied. If the screen is clogged, the meshes are blown clear with a strong stream of salt water. Then the cup is replaced, the entire rig is dropped overboard, and the cable payed out under slight tension.

OCCURRENCE OF MACKEREL-SCAD IN SOUTHERN CALIFORNIA[1]

By Richard S. Croker
California State Fisheries Laboratory
Division of Fish and Game

The first mackerel-scad, *Decapterus sanctae helenae* (Cuvier and Valenciennes), to be recorded for California was taken at Catalina Island on June 25, 1937. It was caught on hook and line, with an anchovy for bait, aboard the pleasure fishing boat *Sunshine II.* J. Charles Davis, 2d, very kindly turned the specimen over to the California Division of Fish and Game. This fish is a member of the family Carangidae and is quite similar in appearance to the common California horse mackerel, *Trachurus symmetricus.* It is likely that other individuals have been taken in California waters, but because of their similarity to the horse mackerel have been confused with it and not reported.

The specimen was 21 inches (53 centimeters) in total length, far larger than most fish of the same and related species recorded from other parts of the world. It was brilliant in color, being bluish-green on the back with a wide orange-red stripe along the lateral line. There was a black spot at the posterior edge of the opercle.

Until we have more specimens at hand this fish can only be tentatively designated as *Decapterus sanctae helenae.* The differences between the generally recognized species of *Decapterus* are at the best slight, and being based on small numbers of usually immature specimens are far from conclusive. The present fish is presumably a mature individual, hence some of the characters given for various species of *Decapterus,* based on immature specimens and which change with age (teeth, length of pectoral fin, body shape, etc.) do not fit. However, it could be assigned to any of several of the species recognized by Norman (1935). Similarly, it could be identified as several of the species recognized by Nichols (1936), who does not agree in all details with Norman's analysis of the genus. According to Walford (1937) it would most likely be *D. sanctae helenae.* The accompanying chart lists the characters of those species most easily confused.

An enumeration of the diagnostic characters of our specimen is as follows: vomerine teeth present but minute, in a T-shaped patch; palatine teeth absent; minute teeth on tongue; gill rakers on lower part of anterior arch 38; length of pectoral 1.34 in head; scales in lateral line 90 plus about 28 more or less well-developed scutes at posterior end (it is difficult to determine at which point the normal scales end and the scutes begin; also the number varies as there are 27 on one side and 29 on the other); the first scutes begin below posterior portion of second dorsal fin; second dorsal with 33 rays; anal with 28 rays.

[1] Submitted for publication, August, 1937.

The genus *Decapterus* is cosmopolitan in warm seas, and it is within reason to suspect that geographical races of one or two root species have developed. It seems likely that the various forms found in the Atlantic Ocean, Indian Ocean, western Pacific and eastern Pacific are all races of the one species originally named *Caranx sanctae helenae* by Cuvier and Valenciennes in 1833.

Diagnostic Characters of Certain Species of Decapterus*

	Catalina Island specimen	*D. sanctae helenae*	*D. hypodus*	*D. lajang*	*D. pinnulatus*	*D. macrosoma*	*D. muroadsi*
Total scales in lateral line	119 or 120	122 to 130	105 to 115	125 to 127	120 to 125	115 to 123	106 to 108
Scutes only	27 to 29	22 to 25	30 to 33	27 to 28	20 to 25	28 to 30	26 to 28
Pectoral fin in head	1.34	1.2 to 1.6	1.5	1.2 to 1.4	1.6 to 1.67	1.5	----------
Gill rakers, lower part of anterior arch	38	32 to 41	32	30	37	33 to 35	----------
Rays in second dorsal fin	33	30 to 35	32 or 33	34 or 35	32 or 33	34 or 35	33
Rays in anal fin	28	26 to 30	25 to 27	28 to 31	28 or 29	28 to 30	28
Palatine teeth	Absent	Absent	Present, feeble	Present	Usually absent	Absent	----------
Vomerine teeth	Present	Sometimes absent	Present	Present	Apparently none	Present	----------
Teeth on tongue	Present	Sometimes present	Present	Present	Present	Present	----------
Habitat as given	California	Atlantic	Pacific coast of Mexico	East Africa to Japan	Polynesia	East Africa to Japan	Japan

* Characters as given by Norman (1935), except that those for *D. muroadsi* are from Nichols (1936).

A second specimen, undoubtedly the same species although it was only superficially examined, was seen by the writer at San Diego on August 16, 1937. It had been taken that day on hook and line at Los Coronados Islands, Lower California, aboard the pleasure fishing boat *Sportfisher II*. It was almost identical in size with the first specimen.

The San Diego pleasure party boats fishing at Los Coronados Islands during the summer of 1937 have frequently reported horse mackerel when making out their daily catch records. It seems probable that many of these were in reality mackerel-scads. Although the common horse mackerel averages one to two pounds in weight, these reports have indicated an average size of two to four pounds. Furthermore the ordinary horse mackerel does not frequently bite on the live bait customarily used on the San Diego fishing boats.

The definite record of the capture of these two fish is interesting in that it helps to run down the persistent rumor of large "horse mackerel" in Lower California waters. For about a year we have been hearing of large schools of fish that looked like horse mackerel. Tuna fishermen have reported catching quantities of them near Cerros Island, San Benito Islands and Turtle Bay. They said the fish were much larger than the common horse mackerel, running around three to four pounds. Unlike the horse mackerel, they would come up to the surface and take the feather lures used for tuna, even when tuna were schooled and biting. Other fishermen have reported seeing and catching numbers of fish similar to horse mackerel in the southern part of Sebastian Viscaino Bay, Lower California. They were schooled with Pacific mackerel. These fish, which are sometimes present by the thousands, are said to average about three pounds in weight. Their coloration,

light blue on the back with a faint yellowish stripe, has caused the fishermen to distinguish them from the ordinary horse mackerel.

It is my belief that these various reports can all be considered as referring to *Decapterus sanctae helenae*. This would indicate a large population of this little known fish along the Lower California coast, and extending into southern California. It is hoped that additional specimens can be obtained which may serve to throw further light on this complex genus.

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EDITORIALS and NOTES

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DUCKS UNLIMITED

The decline in the numbers of wild ducks and geese in North America has reached alarming proportions. Several factors contribute to the decline, and many remedies have been proposed. There is no doubt, however, that the basic cause of this depletion is the destruction of breeding grounds, both by drought and by the encroachment of agriculture. It is essential that wildfowl breeding grounds be restored. The U. S. Biological Survey and several state conservation agencies have made a good start by flooding considerable areas in the United States and restoring them as breeding grounds (*California Fish and Game*, vol. 23, no. 1, pp. 59-66). However, most of the ducks are produced on Canadian breeding grounds, which are in poor condition due to several years of drought, and some of which have been ruined by conversion to wheat fields. It would not be fair to ask Canadian authorities to spend money raising ducks for American hunters to kill, as it is a fact that most of the shooting is done in the United States. Hence, prominent sportsmen and conservationists in both countries have banded together, forming an organization that will go a long way toward restoring the "good old days" so dear to the memory of the wildfowler. This organization is supported, as one editor said, "by those who like to shoot ducks, by those who like to eat the ducks their friends shoot and by those who like the sight of all wildlife in its natural state."

It is believed that the readers of *California Fish and Game* would be interested in hearing of this international movement to restore the duck population of North America. In a previous issue (vol. 23, no. 1, pp. 31-35), John C. Huntington, vice president, More Game Birds in America, a Foundation, described existing conditions and outlined the fact finding work of his organization. In response to our queries regarding recent progress and aims, John B. Coleman, State Chairman of Ducks Unlimited has written us under date of August 26, 1937, as follows:

"In answer to your request for further information regarding the project 'Ducks Unlimited,' I will give you my idea as to what it stands for and means:

"Ducks Unlimited was financed by More Game Birds in America, a Foundation, which furnished the funds to organize all the States in the Union, appointed chairmen through the different States and allocated a quota to each State based on the number of hunters and amounts invested in duck grounds. The different States are now at work on their quotas which, in the aggregate, will total $600,000 per year for the period of five years, or a total of $3,000,000 in subscriptions.

"Ducks Unlimited presents a practical plan to perpetuate and steadily improve the duck situation in the United States by the production of millions of more wild ducks annually, through the restoration and business-like management of the Canadian duck breeding grounds. The possibilities of increasing the duck situation are unlimited and without any doubt the work of the organization, when fully on its way, should show an increase of millions of ducks annually. It surely presents an opportunity for the sportsmen of this country to end the 'Duck Depression' and the cost will be insignificant when compared with the results.

"The starting point in this work will be the restoration and rehabilitation of those large areas in the Canadian Provinces of Alberta, Saskatchewan and Manitoba, where it is estimated about seventy-five to eighty per cent of our duck population is annually produced. Ducks Unlimited proposes to spend $600,000 annually in the Canadian area for a period of five years in acquiring lands, land development, management of lands, supervision and improvements, fact-finding, etc. Canada already is doing her share and is willing to do more by setting aside hundreds of thousands of acres. They have organized and incorporated Ducks Unlimited (Canada) and appointed four directors who will serve in conjunction with a like number from the United States. These public-spirited sportsmen will serve without remuneration and have complete charge of the program.

"The necessary work will involve—

1. Preservation of existing breeding grounds in the zone above mentioned and competent supervision of such areas to assure their continued productivity.
2. Restoration of former exceedingly productive breeding grounds by reconditioning those which still exist but whose usefulness has been impaired; and managing such areas so as to assure maximum duck crops.
3. Controlling predators, preventing disease and impounding water, all of which will materially increase the duck crop.
4. Setting aside the most productive duck breeding areas as permanent sanctuaries by the Canadian Government.

"Every dollar contributed to Ducks Unlimited will be spent to promote more ducks in Canada where duck restoration dollars will produce the best results.

"The major items for the five year program are as follows:

Land acquisition	$700,000
Land development	1,350,000
Management of lands	350,000
Miscellaneous activities in the southern zone	80,000
Supervision and improvements on public lands	220,000
Fact-finding	60,000
Overhead	210,000
Total	$2,970,000

"In order to carry out this extensive program efficiently, to avoid costly errors and to obtain the best possible returns in the shape of

more ducks for each dollar expended, a sound, well-managed business organization is necessary. Such an organization is Ducks Unlimited (Canada), a nonprofit corporation, incorporated under the laws of the Dominion of Canada, which will be assisted in every way by Ducks Unlimited (United States).

"Subscribers to Ducks Unlimited are thereby assured of careful and efficient expenditure of the funds they contributed.

"It is the opinion of the New York office that work will be started in Canada after the first thaw in the spring of 1938.

"In all my forty years' experience hunting in California, I have never had a proposition submitted to me so appealing and worthy of the support of every sportsman in the country."

OCEAN SUNFISH IN SAN PABLO BAY

The ocean sunfish, *Mola mola*, belonging to the head-fish family Molidae, looks as if it might be only the head of a large fish and that someone had forgotten to attach a body and regulation tail. This odd looking animal has a caudal fin but it is little more than a ragged fringe along the posterior side of the body. Supposedly the circular shape of the body and its flattened or compressed appearance suggested a mill-wheel to Linnaeus for he named it "mill-wheel" (mola).[1] The weird appearance of this fairly common fish has been useful to imaginative newspaper reporters and about every two years the papers carry a picture of the sunfish with a story of a creature unknown to everyone along the waterfront.

This fish is often caught in the nets of sardine fishermen operating off San Francisco, Monterey, San Pedro and San Diego. It seems to be especially abundant in Monterey Bay where it is seen turned on its side idling at the surface as though sunning itself. Usually the fish is only 2 or 3 feet long, but one landed at Redondo Beach in southern California was 8 feet 2 inches long and weighed 1,200 pounds. One, only slightly smaller than this, was caught at San Diego three years ago, and large specimens are sometimes seen at Monterey.

Occasionally there are reports of this fish having been seen in San Francisco Bay. There is a definite record of a 7¾-pound sunfish caught August 9, 1937, on hook and line at the Mare Island Lighthouse at the lower end of Carquinez Strait. A few days before this, a sunfish is said to have been gaffed in Mare Island Strait, so it is evident that ocean sunfish do occasionally invade upper San Pablo Bay as far as Carquinez Strait.

This fish is supposed to be a plankton feeder, eating only minute organisms from the water, but the 7½-pound fish mentioned above was taken on a hook baited with a piece of sardine. Another *Mola* was reported as being taken on hook and line during the summer of 1937. It was caught off San Pedro on a hook baited with a live anchovy. These occurrences are not unprecedented, however, for there are other instances of plankton feeders that vary the monotony by taking baited hooks occasionally.—*W. L. Scofield, California State Fisheries Laboratory, August, 1937.*

[1] See the photograph of the sunfish in "Calif. Fish and Game," vol. 22, no. 1, p. 49, 1936.

RECORD MACKEREL TAKEN AT MONTERY

The largest Pacific mackerel, *Pneumatophorus diego,* on record was landed at Monterey, California, on August 11, 1937. The fish measured 24½ inches in total length and weighed exactly six pounds. Its greatest depth, from back to belly, was five inches.

Manuel Balesteri and his crew caught this huge mackerel in a lampara net haul, along with 1,000 pounds of ordinary mackerel, about one mile east of the Pt. Pinos Lighthouse, near Pacific Grove.

The largest mackerel taken along the Pacific Coast seldom are more than 20 inches long or over three pounds in weight. The previous definite size record was of an individual taken at San Pedro that was 22¼ inches in length and 3½ pounds in weight.—*J. B. Phillips, California State Fisheries Laboratory, August 16, 1937.*

FUR-BEARING MAMMALS OF CALIFORNIA

One of the greatest pleasures an editor can have is to review a book of the caliber of the one under discussion. *Fur-bearing mammals of California, their natural history, systematic status, and relations to man,* by Joseph Grinnell, Joseph S. Dixon and Jean M. Linsdale [1] is a fine example of what a book on natural history should be but not always is. Its treatment of the field it sets out to cover is complete from every standpoint. Its style is such that the beginning student can understand it, and reading it be inspired to go forth and learn more about fur-bearers in the wild. Yet its pages of factual information contain many details that no one wildlife investigator could ever hope to run across in the field. The typography, reproduction of illustrations and general makeup are in the usual manner of the University of California Press—that is to say, splendid.

Many years ago the authors laid plans for the publication of a treatise on the fur-bearers of California. Rather than rush to press with a sketchy account they took their time and evolved the book which will stand as a model in its field. In general the material presented was derived from four sources. First of all were the field and laboratory observations of the authors. Supplementing these were the notes of their students. The published observations of other scientists and historians furnished considerable information. Perhaps the most interesting parts are those based on the observations of outdoor men who were contacted personally or by letter. The outside sources of material included trappers, hunters, stockmen, "old settlers," Division of Fish and Game employees, U. S. Forest Service and National Park officers, and nature lovers in general. All outside material, as well as the authors' own, was carefully checked. Division of Fish and Game records of trappers' catches were used.

The field covered by the term "fur-bearing mammal" is explained by the authors as follows: "The restricting definition for 'fur-bearing mammal' is that a given kind, in order to warrant inclusion in our treatise, must have had positive commercial value as a producer of 'furs.' Out of about 60 'groups' of free-living mammals in California,

[1] Contribution from the Museum of Vertebrate Zoology, University of California. University of California Press, Berkeley, 1937.

25 meet this definition and are therefore given more or less extended attention. It is true that certain other groups, such as moles, gray squirrels, and jack rabbits, have occasionally been levied upon and their pelts marketed; but this has happened so rarely, or in such meager measure, that we have not felt justified in including them among the fur producers worth serious consideration."

The animals discussed are: opossum, bears, coons, ring-tailed cats, martens, fisher, weasels, mink, wolverine, otters, skunks, badgers, foxes, coyotes, wolf, mountain lion, wildcats, fur seals, beavers and muskrats. Under each species are the pertinent details in fine type, followed by a discussion in large type of the natural history, abundance and importance of the animal.

Preceding the accounts of the individual species are several chapters of great interest dealing with the history of fur trapping in California, present day fur trapping, effects of fur mammals upon the activities of man, effects of the activities of man upon fur mammals, population trends of fur-bearers, and fur farming.

Throughout, the authors impress us with the need for conservation of our fur-bearers. Although they admit that certain species are detrimental (to a greater or less extent) to livestock, poultry, crops or game, they stress the point that on the whole the fur-bearing group is of great positive economic value. For example, many fur-bearers prey upon destructive rodents, insects and other "vermin," thus saving the farmer untold thousands of dollars. Furthermore, the monetary value of the California fur crop is considerable (estimated at $220,000 in 1924), and this harvest can be maintained at a high level as long as over-trapping does not occur. Some of the species are usful as game, some as food, and all are valuable in that they bring pleasure to nature lovers who are fortunate enough to see them in their natural haunts.

The two volumes of *Fur-bearing mammals of California* contain 777 pages, 13 colored plates and 345 figures. The colored paintings of animals were made by Major Allan Brooks, and are up to his usual high standard. The figures consist of line drawings to illustrate structural details, and photographs and wash drawings of the animals, their homes and their habitat. A bibliography and an index complete the book.—*Richard S. Croker, Editor, California Fish and Game.*

REPORTS

DEPARTMENT OF NATURAL RESOURCES, DIVISION OF FISH AND GAME, STATEMENT OF REVENUE

For the Period July 1, 1936, to June 30, 1937, of the Eighty-eighth Fiscal Year

	Detail	Total
Revenue for the Fish and Game Preservation Fund, Current Year		
License sales:		
Angling licenses, 1936	$441,686 50	
Angling licenses, 1937	147,116 95	
Commercial hunting club licenses, 1936-1937	750 00	
Commercial hunting club operators' licenses, 1936-1937	145 00	
Deer tags, 1936	126,852 00	
Deer tags, 1937	2 00	
Fish breeders' licenses, 1936	30 00	
Fish breeders' licenses, 1937	340 00	
Fish importers' licenses, 1936	5 00	
Fish importers' licenses, 1937	80 00	
Fish packers and wholesale shellfish dealers licenses, 1936-1937	1,130 00	
Fishing party vessel permit, 1937	231 00	
Fishing party vessel permit, 1936	59 00	
Game breeders' licenses, 1936	120 00	
Game breeders, 1937	1,075 00	
Hunting licenses, 1934-1935	661 16	
Hunting licenses, 1935-1936	19,851 00	
Hunting licenses, 1936-1937	414,225 50	
Hunting licenses, 1937-1938	60 00	
Kelp licenses, 1936	10 00	
Kelp licenses, 1937	20 00	
Market fishermen's licenses, 1936-1937	41,760 00	
Market fishermen's licenses, 1937-1938	32,690 00	
Trapping licenses, 1936-1937	2,093 00	
Total licenses sales		$1,230,993 11
Other income:		
Court fines	$63,094 02	
Fish packers tax	317,052 19	
Fish tag sales	2,727 54	
Game tag sales	211 17	
Importers' contributions	230 00	
Interest on bank balances	6,086 10	
Kelp tax	174 80	
Lease of kelp beds	1,592 80	
Miscellaneous sales	5,651 24	
Publication sales	249 43	
Salmon tax—Chap. 1015-35	22,893 18	
Total other income		$419,962 47
Prior year revenue 87th fiscal year—		
Publication sales	$45 74	
		$45 74
Total revenue for the Fish and Game Preservation Fund		$1,651,001 32
Revenue for the General Fund—		
Unclaimed checks and deposits		2 25
Grand total, all funds		$1,651,003 57

STATEMENT OF EXPENDITURES

For the Period July 1, 1936, to June 30, 1937, of the Eighty-eighth Fiscal Year

Function	Salaries and wages	Materials and supplies	Service and expense	Property and equipment	Total
OPERATING EXPENDITURES, EIGHTY-EIGHTH FISCAL YEAR					
Administration:					
Executive	$5,000 00				$5,000 00
General office	5,670 00	$1,701 34	$1,487 68	$250 31	9,109 33
Printing, general		4,148 39			4,148 39
Printing Fish and Game Magazine		1,623 86			1,623 86
Automobiles		364 27	218 77		583 04
Traveling			2,294 56		2,294 56
Postage			4,105 38		4,105 38
Telephone and telegraph			4,175 44		4,175 44
Freight, cartage and express			848 71		848 71
Rent			11,017 61		11,017 61
Accident and death claims			3,734 55		3,734 55
Departmental administration, pro rata	12,233 95		266 05		12,500 00
Librarian	1,650 00	188 23	72 63	140 02	2,050 88
Legal			4,770 83		4,770 83
Premiums on bonds			35 00		35 00
Publicity			1,238 22		1,238 22
Pro rata General Fund expense, Chap. 923-33			6,496 93		6,496 93
Sales tax on sales			—7 78		—7 78
Temporary help	394 19				394 19
Total Administration	$24,948 14	$8,026 09	$40,754 58	$390 33	$74,119 14
Patrol and Law Enforcement:					
Chief and assistants	$14,653 06				$14,653 06
General office	4,852 51	$263 78	$49 22	$68 17	5,233 68
Automobiles		35,539 27	15,114 81	26,138 20	76,792 28
Traveling			50,603 89		50,603 89
Postage			793 17		793 17
Telephone and telegraph			2,498 33		2,498 33
Freight, cartage and express			2 73		2 73
Rent			876 48		876 48
Heat, light, water and power			8 72		8 72
Captains and wardens	205,685 86	645 37	1,092 37	115 41	207,539 01
Launches	9,986 44	11,801 14	7,305 93	23,510 43	52,603 94
Premiums on bonds			63 48		63 48
Temporary help	1,642 29				1,642 29
Assistant fish and game wardens, seasonal	22,814 03				22,814 03
Total Patrol and Law Enforcement	$259,634 19	$48,249 56	$78,409 13	$49,832 21	$436,125 09
Commercial Fisheries:					
Chief and assistant	$10,440 00				$10,440 00
General office	8,419 11	$46 24	$25 34	$278 83	8,769 52
Automobiles		680 17	332 46	623 15	1,635 78
Travel			7,343 61		7,343 61
Telephone and telegraph			829 90		829 90
Freight, cartage and express			223 92		223 92
Rent			151 51		151 51
Heat, light, water and power			623 19		623 19
Research, oyster	2,280 00	66 59			2,346 59
Laboratory	30,062 42	2,361 55	1,712 52	2,375 69	36,512 18
Fish tags		327 33			327 33
Cooperative Research		30 38	16,000 00		16,030 38
Statistics		1,353 29	2,110 39	255 21	3,718 89
Temporary help	897 09				897 09
Terminal Island grounds	1,050 00	26 23	9 43	7 67	1,093 33
Fish cannery auditing			2,665 00		2,665 00
Total Commercial Fisheries	$53,148 62	$4,891 78	$32,027 27	$3,540 55	$93,608 22
Fish Conservation:					
Chief and assistant	$6,865 81	$4 53			$6,870 34
General office	4,838 12	12 26	$13 15	$22 19	4,885 72
Automobiles		10,793 10	4,397 27	5,896 31	21,086 68
Travel			10,062 47		10,062 47
Postage			184 34		184 34
Telephone and telegraph			1,192 66		1,192 66
Freight, cartage and express			573 90		573 90
Rent			1,875 49		1,875 49
Heat, light, water and power			2,338 32		2,338 32
Research (oyster)		105 51	309 17	82 03	496 71
Fish planting		605 69	1,754 77	583 50	2,943 96
Hatcheries	109,402 08	59,258 10	943 50	1,079 29	170,682 97
Fish cars	1,800 00	1 44	962 64		2,764 08
Blue printing			6 85		6 85

STATEMENT OF EXPENDITURES—Continued

For the Period July 1, 1936, to June 30, 1937, of the Eighty-eighth Fiscal Year

Function	Salaries and wages	Materials and supplies	Service and expense	Property f and equipment	Total
Fish Conservation—Continued					
Cooperative research	$2,263 23	$191 13	$180 14	$21 33	$2,655 83
Statistical	1,598 71	77	1,122 99		2,722 47
Temporary help	1,093 69				1,093 69
Special field	13,880 00	88 67	10 71	11 49	13,990 87
Fish rescue	1,920 00	41	25 50		1,945 91
Assistant fish and game wardens—seasonal	32,670 06				32,670 06
Total Fish Conservation	$176,331 70	$71,061 61	$25,953 87	$7,696 14	$281,043 32
Hydraulics:					
Chief and assistant	$7,677 96				$7,677 96
General office	1,920 00	$72 78	$5 86	$26 32	2,024 96
Automobiles		364 58	87 20	10 97	462 75
Traveling			2,287 32		2,287 32
Telephone and telegraph			1 20		1 20
Blue printing		1 65	72 45		74 10
Temporary help	84 64				84 64
Total hydraulics	$9,682 60	$439 01	$2,454 03	$37 29	$12,612 93
Game Conservation:					
Chief and assistants	$16,033 29				$16,033 29
General office	4,035 00	$99 72	$27 60	$36 77	4,199 09
Automobiles		2,053 20	714 80	2,623 14	5,391 14
Traveling			4,538 34		4,538 34
Telephone and telegraph			418 33		418 33
Freight, cartage and express			131 13		131 13
Heat, light, water and power			3,333 91		3,333 91
Maintenance of game farms	12,098 97	17,104 18	560 40	3,039 09	32,802 64
Statistics	758 87	1 22	1,101 20		1,861 29
Temporary help	8,486 46				8,486 46
Maintenance of game refuges	4,358 00	2,308 39	751 70	705 52	8,123 61
Total Game Conservation	$45,770 59	$21,566 71	$11,577 41	$6,404 52	$85,319 23
Licenses:					
General office	$14,850 00	$923 50	$215 60	$27 16	$16,016 26
Printing licenses and applications		3,466 93			3,466 93
Traveling			384 27		384 27
Postage			1,136 13		1,136 13
Freight, cartage and express			43 39		43 39
Premiums on bonds			1,253 67		1,253 67
Identification license buttons		9,657 21			9,657 21
License commissions			54,993 46		54,993 46
Total licenses	$14,850 00	$14,047 64	$58,026 52	$27 16	$86,951 32
Special Item:					
State Fair and other exhibits (payable from support, Chap. 341-35 or E. O. for support)	$40 00	$117 37	$1,200 00		$1,357 37
Total eighty-eighth fiscal year expense paid from support appropriations	$584,405 84	$168,399 77	$250,402 81	$67,928 20	$1,071,136 62
Prior year, eighty-seventh fiscal year for support					54 34
Total eighty-seventh and eighty-eighth fiscal years for support					$1,071,190 96
Special Items:					
Predatory Animal Control:					
Eighty-eighth fiscal year:					
Chief and assistant	$3,700 00				$3,700 00
General office	897 72			$25 00	922 72
Automobiles		$3,321 63	$964 67	650 87	4,937 17
Traveling			3,152 36		3,152 36
Predatory animal control	20,765 76	1,420 37	6,354 99	15 14	28,556 26
Predatory animal hunters and trappers, seasonal	6,000 00				6,000 00
Freight, cartage and express			4 65		4 65
Total eighty-eighth fiscal year	$31,363 48	$4,742 00	$10,476 67	$691 01	$47,273 16
Total expenditures, eighty-seventh and eighty-eighth fiscal years					$1,118,464 12

STATEMENT OF EXPENDITURES—Continued

For the Period July 1, 1936, to June 30, 1937, of the Eighty-eighth Fiscal Year

Function	Salaries and wages	Materials and supplies	Service and expense	Property and equipment	Total
Expenditures for Additions and Betterments:					
Permanent Improvements:					
Purchase of game refuges and public shooting grounds, and C. I. E. Chapter 341-35	$16,094 67	$26,221 94	$8,729 14	$18,596 26	$69,642 01
Contribution to Employees' Retirement System, eighty-eighth fiscal year					17,035 24
Total current biennium					$1,205,141 37
Special Item:					
Construction of Russian River jetties, Chapter 989-33:					
Eighty-eighth fiscal year			$215 25		$215 25
California Code Commission, Chap. 645-33			1 50		1 50
Total operating expenditures, eighty-eighth fiscal year			$216 75		$216 75
Grand totals					$1,205,358 12

SEIZURES OF FISH AND GAME

April, May, June, 1937

Game:	
Deer	3
Deer hides	3
Deer meat, pounds	596
Dove	8
Ducks	17
Grouse	1
Pheasant	12
Quail	4
Rabbits	15
Wood duck	1
Fish:	
Abalone	286
Barracuda, pounds	625
Bass, black	138
Bass, striped	51
Bass, striped, pounds	50
Bass, white sea, pounds	30
Carp	20
Catfish	25
Clams	1,536
Cockles	1,227
Crabs	289
Crappie	39
Grunion, pounds	10
Lobsters	321
Lobster traps	12
Minnows	11
Perch	51
Salmon, pounds	31
Sunfish	192
Trout	310
Trout, pounds	6½
Yellowfin tuna, pounds	3,509
Fishing rod	1
Reel and line	1

FISH CASES

April, May, June, 1937

Offense	Number arrests	Fines imposed	Jail sentences (days)
Abalones; out of shell; overlimit; undersize; taken in less than 20 feet of water	92	$1,662 50	16½
Anchoring; closed district	2	150 00	
Barracuda; undersize	1		
Bass, black; closed season; overlimit; undersize; spearing	15	180 00	10
Bass, striped; overlimit; selling; undersize; failure to deliver to Fish and Game Commission	22	370 00	90
Bass, white sea; overlimit	1	150 00	
Clams: from refuge; overlimit; undersize	44	670 00	369½
Cockles; overlimit; undersize	3	15 00	
Commercial fishing; no license	15	182 50	
Crabs; holding in live box; undersize	51	915 00	70
Failure to record fish purchased	1	25 00	
False statement, license application	1	10 00	
Fishing; no license; transferring license; using another's license; failure to show license on demand; using, possession prohibited gear; closed season; closed district; through ice; too near dam, ladder, traps; taking brood fish from hatchery	217	2,675 50	179
Fishing tackle in refuge	1	25 00	
Frogs; undersize	1	10 00	
Grunion; closed season	1		
Lobster; closed season	2		
Minnows transported	1	50 00	
Night fishing	3	35 00	
Pollution	17	530 00	
Sunfish; closed season; overlimit	19	180 00	
Trout; closed season; closed stream; overlimit; selling	24	520 00	10
Using fresh spawn	3	150 00	
Using explosives to take fish	1	100 00	
Totals	538	$8,605 50	745

GAME CASES

April, May, June, 1937

Offense	Number arrests	Fines imposed	Jail sentences (days)
Beaver hide; possession	2	$10 00	
Deer; closed season; killing, possession fawn, doe; possession spotted fawn	42	1,345 00	554
Destroying bird nests	1	25 00	
Doves; closed season	7	165 00	
Ducks; closed season	13	367 50	
False statement, license application	3	30 00	
Firearms in refuge	4	30 00	
Grebe; possession	1	5 00	
Grouse; possession	1	50 00	
Hunting; in refuge; no license	26	196 00	105
Illegal shooting	4	85 00	
Interfering with officer discharging his duties	1		
Mudhen; closed season	1	10 00	
Night hunting	1	25 00	
Non-game birds; possession	4	15 00	6
Pheasant; closed season; overlimit	14	447 50	6
Quail; closed season	5	160 00	
Rabbits; closed season	3	35 00	
Shorebird; possession	1		
Spotlight hunting	3		125
Trapping, no license	34	217 50	
Tree squirrel; possession	2	20 00	
Totals	173	$3,238 50	796

ARRESTS AND CONVICTIONS FOR VIOLATION OF FISH AND GAME CODE

July, 1935—June, 1937

Offense	Number arrests	Fines imposed	Jail sentences (days)
Fish cases, 1935-1936	1,316	$23,031 00	1,947½
Game cases, 1935-1936	1,070	25,211 49	6,841
Totals, 1935-1936	2,386	$48,242 49	8,788½
Fish cases, 1936-1937	1,618	$31,094 50	2,223½
Game cases, 1936-1937	1,480	40,122 06	5,933½
Totals, 1936-1937	3,098	$71,216 56	8,157
Recapitulation—			
1935-1936	2,386	$48,242 49	8,788½
1936-1937	3,098	71,216 56	8,157
Totals	5,484	$119,459 05	16,945½

TOTAL ARRESTS FOR A PERIOD OF THIRTY-FIVE YEARS

1902-1904	550
1904-1906	774
1906-1908	1,192
1908-1910	1,771
1910-1912	2,063
1912-1914	1,993
1914-1916	2,087
1916-1918	1,797
1918-1920	1,891
1920-1922	2,258
1922-1924	2,715
1924-1926	3,207
1926-1928	4,390
1928-1930	5,388
1930-1932	5,237
1932-1934	3,795
1934-1936	4,535
1936-1937	3,098

SEIZURES OF FISH AND GAME

Fish	July 1, 1935, to June 30, 1936	July 1, 1936, to June 30, 1937	Total
Abalone	1,246	1,037	2,283
Abalone, pounds	50	2,856	2,906
Abalone slices	1		1
Barracuda	3	125	128
Barracuda, pounds	5,267½	825	6,092½
Bass—			
Black	145	255	400
Black, pounds	5½		5½
Rock	1	4	5
Striped	601	438	1,039
Striped, pounds	557	250	807
White sea, pounds	1,150	69	1,219
White sea, barrels		60	60
Blue cod, pounds		4	4
Carp	20	20	40
Catfish		46	46
Catfish, pounds	1,275	70	1,345
Clams	6,820	5,860	12,680
Cockles	2,100	1,227	3,327
Cockles, pounds		225	225
Crabs	70	536	606
Crabs (cooked)	240		240
Crappie, perch, sunfish	961	433	1,394
Croaker, yellowfin	40	1	41
Grunion, pounds		10	10
Halibut, pounds	400		400
Live car	2	1	3
Lobsters	1,107	1,012	2,119
Lobsters, pounds	75	330	405
Lobster receivers	2	3	5
Lobster traps	197	12	209
Minnows		11	11
Mullet, pounds	157		157
Mussels, pounds	100		100
Salmon	31	76	107
Salmon, pounds	1,775	381	2,156
Shad, pounds	30		30
Skeins of fresh trout roe	2		2
Skipjack, pounds		52,157	52,157
Spears	2		2
Sturgeon, pounds		62	62
Trammel, net		1,500 ft.	1,500 ft.
Traps		11	11
Trout, steelhead	1,116	1,615	2,731
Trout, pounds	311½	156½	468
Tuna, pounds	7,636	6,421	14,057
Yellowfin, pounds		85,025	85,025
Yellowtail		1	1

SEIZURES OF FISH AND GAME—Continued

Game	July 1, 1935, to June 30, 1936	July 1, 1936, to June 30, 1937	Total
Bear		1	1
Deer	57	65	122
Deer feet	6		6
Deer heads	1	2	3
Deer hides	22	36	58
Deer meat	4 quart jars		4 quart jars
Deer meat, pounds	5,370	3,207½	8,577½
Doves	1,058	750	1,808
Ducks, geese, mudhens	584	2,638	3,222
Eagle		1	1
Egret	26		26
Godwit, marbled	2		2
Grebe	1	2	3
Grouse		5	5
Larks, horned	3		3
Meadowlark	10	4	14
Nongame birds	54	143	197
Owl	1		1
Pheasants	58	154	212
Pigeons	1	1	2
Plover	8	52	60
Quail	242	709	951
Rabbits	90	94	184
Rail		1	1
Robins	16		16
Shorebirds	8		8
Sparrow	1		1
Squirrels	4	2	6
Swan	3	4	7
Snipe	33		33
Tree squirrel		1	1
Tree squirrel hides		3	3
Wood duck		1	1
Woodpecker		3	3

GAME CASES

Offense	July 1, 1935, to June 30, 1936			July 1, 1936, to June 30, 1937		
	Arrests	Fines	Jail, days	Arrests	Fines	Jail, days
Antelope; possession buck				3	$100 00	
Bear; closed season	1		75			
Beaver hide; possession				2	10 00	
Bird nets; possession				1	25 00	
Concealed weapon carried				1	25 00	
Deer; closed season, district; killing, possession does, fawns, spike bucks, spotted fawns; evidence of sex removed; failure to tag; tags altered, mutilated, not returned; dogs running deer; failure to retain hide and horns; failure to mark packages	354	$11,160 00	3,757½	403	12,839 50	3,761½
Doves; closed season; overlimit	57	1,295 00	110	71	2,870 00	
Ducks, geese, mudhens; closed season; overlimit; sale	58	2,790 00	300	144	7,695 00	1,385
Eagle; possession				1	100 00	
Elk; possession				3		
Firearms in refuge; illegal possession of	46	606 00	39½	65	825 00	89½
Game birds; closed season				6	85 00	
Grebe; possession				1	5 00	
Grouse; closed season				5	360 00	
Hunting; no license, illegal license; false statement; in refuge; closed district; borrowing, transferring license; alien using citizen's license; failure to show game on demand; failure to show license on demand	275	3,746 00	1,549½	295	4,253 50	237½
Illegal shooting	26	450 00		88	1,607 50	11
Night hunting	5	65 00		16	410 00	
Nongame birds; killing, possession	45	585 00	32½	56	1,047 50	16
Pheasant; closed season; snaring; possession untagged; overlimit; shipping in closed packages	48	1,120 00	260	104	3,517 50	71
Pigeon; closed season	6	70 00	12½	2	25 00	
Protected birds; possession, killing	2	105 00		17	255 00	120
Quail; closed season; using for bait; overlimit; failure to tag domesticated; trapping	47	1,637 50	76	58	1,408 56	95
Rabbits; closed season; netting of	28	390 00		35	741 00	2
Spotlighting	39	725 00	252	32	1,195 00	135
Trapping; no license	3	70 00		38	219 50	10
Tree squirrels; killing, possession				9	145 00	
Trespassing				13	132 50	
Miscellaneous game cases	27	296 99	376½	11	225 00	
Totals	1,067	$25,111 49	6,841	1,480	$40,122 06	5,933½

FISH CASES

Offense	July 1, 1935, to June 30, 1936			July 1, 1936, to June 30, 1937		
	Arrests	Fines	Jail, days	Arrests	Fines	Jail, days
Abalones; drying of; overlimit; undersize; taken below high water line; closed season; out of shell; taken in less than 20 feet of water	165	$3,290 00	50	224	$4,041 50	339
Anchoring, closed district				2	150 00	
Barracuda; closed season; selling undersize; overlimit	12	305 00		4	115 00	
Bass—						
Black; closed season; undersize; overlimit; spearing	13	307 50	160	36	528 00	32
Striped; illegal shipment of; offering for sale; undersize; overlimit; failure to deliver to Fish and Game Commission	97	2,079 00	402	79	1,745 00	205
White sea; undersize; overlimit	1	100 00		6	520 00	
Catfish; closed season; undersize sold; keeping undersize in live car; failing to keep dealer's record	2	10 00				
Clams; overlimit; undersize; taken in clam refuge; out of shell; failure to show on demand; closed season; instrument in preserve; offering for transportation, selling overlimit	199	3,070 00	702½	194	4,044 00	1,127
Cockles; overlimit; undersize	3	75 00		3	15 00	
Commercial fishing; no license; no reports; boat not registered	138	990 00	40	138	997 50	5
Crabs; female; undersize; shipping in from closed district; holding in live box; closed season	41	700 00	20	96	1,660 00	100
Crappie, perch, sunfish; overlimit; closed season	16	270 00		24	270 00	
Failure to record fish purchased				1	25 00	
Fish wastage	5	255 00		3	100 00	
Fishing; from dam; too near dam, fishway, ladder, traps; closed stream; no license; failure to provide passage over dam; closed district; using, possession prohibited gear; failure to show license on demand; transferring license; using another's license; false statement on license application; through ice; taking brood fish from hatchery; using explosives; using fresh spawn	405	7,787 00	438	605	10,225 50	355½
Fishing tackle in refuge				1	25 00	
Frogs; undersize				1	10 00	
Grunion; closed season				1		
Lobsters; closed season; undersize; taken in traps; oversize	15	265 00	12½	20	205 00	10
Minnows transported				1	50 00	
Mussels taken in refuge	2		20			
Night fishing	47	559 00	30½	36	575 00	
Operating smokehouse; no packer's license				1		
Pollution	14	550 00		46	2,210 00	
Salmon; illegal taking of; closed season; clubbing; failure to stamp cans; overlimit; undersize; gaffing; transporting; spearing	18	325 00		21	365 00	30
Sardines; illegal use of; exceeding permit tonnage allotment; reducing without permit	4	215 00		5	1,600 00	
Skipjack; selling undersize				3	50 00	
Steelhead; overlimit				2	25 00	
Sturgeon, possession of				1	20 00	
Trout; clubbing; dynamiting; overlimit; closed season; spearing; closed stream; selling	91	1,636 00	42	54	1,173 00	20
Tuna, yellowfin; selling undersize				10	350 00	
Yellowtail; closed season; selling local to cannery	2					
Miscellaneous fish cases	27	342 50	30			
Totals	1,317	$23,131 00	1,947½	1,618	$31,094 50	2,223½

FRESH FISH IMPORTATIONS BY POINT OF ORIGIN* FOR APRIL, MAY AND JUNE, 1937

Compiled by the Division of Fish and Game, Bureau of Marine Fisheries

Species	Gulf of California	West Coast Lower California	International waters south U. S. boundary (definite origin unknown)	Mexican mainland, Central and South America	Japan	Total pounds
Barracuda		184,910	1,075			185,985
Cabrilla	1,307	190	23,926			25,423
Corbina, Mexican	20,175					20,175
Cultus, Pacific		58				58
Grouper	2,508	15,416	712			18,636
Halibut, California		47,467	398			47,865
Mackerel, Pacific		88,802	80			88,882
Mackerel, Spanish		120				120
Perch		340				340
Pompano, Mexican		162				162
Rock Bass		54,367	676			55,043
Rockfish		52,069				52,069
Sculpin		198				198
Sea-bass, Black	104	70,100	28,486			98,690
Sea-bass, Totuava	318,868					318,868
Sea-bass, White		31,185	53			31,238
Shark		1,757	308			2,065
Sheepshead		1,124	380			1,504
Smelt		35				35
Sole		27				27
Swordfish, Broadbill		2,352				2,352
Swordfish, Marlin			490			490
Tuna, Albacore					222,531	222,531
Tuna, Bluefin		589,179	238,220			827,399
Tuna, Bonito		219,728	3,335			223,063
Tuna, Oriental					57,106	57,106
Tuna, Skipjack	523,357	818,167	7,326,210	239,327	4,049,818	12,956,879
Tuna, Yellowfin	394,402	2,086,365	22,583,566	4,969,978		30,034,311
Yellowfish		884	1,459			2,343
Yellowtail	239	1,205,591	73,650			1,279,480
Total pounds	1,260,960	5,470,593	30,283,024	5,209,305	4,329,455	46,553,337

*These importations are included in tables of landings. They include fish caught by California boats in foreign waters as well as frozen fish imported for canning in California plants.

FRESH FISH IMPORTATIONS* FROM FOREIGN COUNTRIES FOR APRIL, MAY AND JUNE, 1937

Compiled by the Division of Fish and Game, Bureau of Marine Fisheries

Species	Landed in Region 70, Los Angeles	Landed in Region 80, San Diego	Total pounds
Barracuda		185,985	185,985
Cabrilla	20,695	4,728	25,423
Corbina, Mexican	20,175		20,175
Cultus, Pacific		58	58
Grouper	2,618	16,018	18,636
Halibut, California		47,865	47,865
Mackerel, Pacific		88,882	88,882
Mackerel, Spanish		120	120
Perch		340	340
Pompano, Mexican		162	162
Rock Bass	400	54,643	55,043
Rockfish		52,069	52,069
Sculpin		198	198
Sea-bass, Black	25,939	72,751	98,690
Sea-bass, Totuava	310,183	8,685	318,868
Sea-bass, White		31,238	31,238
Shark		2,065	2,065
Sheepshead	380	1,124	1,504
Smelt		35	35
Sole		27	27
Swordfish, Broadbill		2,352	2,352
Swordfish, Marlin	490		490
Tuna, Albacore	222,531		222,531
Tuna, Bluefin	720,174	107,225	827,399
Tuna, Bonito	3,588	219,475	223,063
Tuna, Oriental	57,106		57,106
Tuna, Skipjack	9,587,624	3,369,255	12,956,879
Tuna, Yellowfin	12,357,126	17,677,185	30,034,311
Whitefish	1,459	884	2,343
Yellowtail	84,528	1,194,952	1,279,480
Total pounds	23,415,016	23,138,321	46,553,337

*These importations are included in tables of landings. They include fish caught by California boats in foreign waters as well as frozen fish imported for canning in California plants.

CALIFORNIA FRESH FISH LANDINGS* FOR APRIL, MAY AND JUNE, 1937

Compiled by the Division of Fish and Game, Bureau of Marine Fisheries

Species	Region 10, Del Norte	Region 20, Eureka	Region 30, Sacramento	Region 40, San Francisco	Region 50, Monterey	Region 60, Santa Barbara	Region 70, Los Angeles	Region 80, San Diego	Total pounds
Anchovy				72,200	18,885		6,962		98,047
Barracuda						2,656	835,090	352,664	1,190,410
Cabezone				1,650	179	129			1,958
Cabrilla							20,695	4,728	25,423
Carp			6,035						6,035
Catfish			48,015						48,015
Corbina, Mexican							20,175		20,175
Cultus, Pacific	1,578	16,893		117,452	8,249	10		86	144,268
Eel				12					12
Flounder, Starry		301		117,116	4,924				122,341
Flying Fish							13,163		13,163
Grouper							2,618	16,018	18,636
Hake				5,340					5,340
Halibut, California				1,424	2,392	62,630	140,403	96,283	303,132
Halibut, Northern	887	121,181		44,707					166,775
Hardhead			7,100						7,100
Herring, Pacific				862	3,425	6			4,293
Kingfish				3,482	29,768	10	114,809	148	148,217
Mackerel, Horse					21,986		1,334,724	79,626	1,436,336
Mackerel, Pacific					67,546	1,986	4,750,769	2,175,557	6,995,858
Mackerel, Spanish								120	120
Mullet							2,298	4,787	7,085
Perch	552	8,837		32,762	23,928	1,714	12,641	540	80,974
Pike			152						152
Pompano, California					86		752	40	878
Pompano, Mexican								162	162
Rock Bass						4,108	40,190	65,565	109,863
Rockfish	2,712	38,599		285,538	329,966	100,658	41,965	98,502	897,940
Sablefish	105	242,068		20,289	3,084		25,303		290,849
Salmon	222,974	570,091	131,000	569,496	765,890	922			2,260,373
Sand Dab				118,729	4,387	100	1,680		124,896
Sardine				406,350	753,148	583	8,490,362	54,600	9,705,043
Sculpin						84	31,618	680	32,382
Sea-bass, Black					29	2,798	27,969	73,108	103,904
Sea-bass, Short-fin								932	932
Sea-bass, Totuava							310,183	8,685	318,868
Sea-bass, White					3,016	4,452	11,745	71,390	90,603
Sea-trout, California				20					20
Shad			639,803	275	19				640,097

Shark		249		12,335	1,376	57,000	73,697	19,236	163,893
Sheepshead						1,022	9,648	1,124	11,794
Skate				58,445	3,733	13,582	2,957	600	79,317
Smelt		1,351		95,505	22,717	16,855	57,692	711	194,831
Sole				1,732,946	48,157	136,452	1,143	27	1,918,725
Split-tail			1,438						1,438
Sucker			177						177
Swordfish, Broadbill						3,812	23,469	20,589	47,870
Swordfish, Marlin							490		490
Tomcod				208					208
Tuna, Albacore							636,223	252,620	888,843
Tuna, Bluefin							7,548,350	285,705	7,834,055
Tuna, Bonito							2,057,722	593,606	2,651,328
Tuna, Oriental							57,106		57,106
Tuna, Skipjack							9,587,624	3,369,255	12,956,879
Tuna, Yellowfin							12,363,259	17,677,185	30,040,444
Turbot				19,176	2,653		4		21,833
Whitebait	21,049	24,371		4,928	1,250				51,598
Whitefish						446	2,509	884	3,839
Yellowtail							171,387	1,230,754	1,402,141
Miscellaneous Fish		348	11	30,037		408	197		31,001
Crustacean:									
Crab	7,952	49,284		160,543	228				218,007
Crab, Rock						5	235		240
Prawn					416				416
Shrimp				308,160					308,160
Mollusk:									
Abalone					512,375	432,717	46		945,138
Clam, Cockle				231			8,175		8,406
Clam, Gaper				860					860
Clam, Pismo					2,082	51,628			53,710
Clam, Soft-shell				23,516					23,516
Clam, Washington		2,665		999					3,664
Octopus		128		2,366	6,740	107			9,341
Oyster, Eastern				69,933					69,933
Oyster, Japanese			55,498	117,089					172,587
Oyster, Native				18,084					18,084
Squid					65,025	13	1,060		66,098
Total pounds	257,809	1,076,366	889,229	4,453,065	2,707,659	896,893	48,839,107	26,556,517	85,676,645

*Importations of fresh fish from foreign countries included. See foreign importation tables.

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